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NATURAL HISTORY AND SYSTEMATICS OF THE TUNDRA HARE (*LEPUS OTHUS* MERRIAM) IN WESTERN ALASKA

A

THESIS

Presented to the Faculty of the

University of Alaska in partial fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

By

Howard Leroy Anderson, Jr.

Fairbanks, Alaska

May 1974

NATURAL HISTORY AND SYSTEMATICS OF THE TUNDRA HARE

(LEPUS OTHUS MERRIAM) IN WESTERN ALASKA

RECOMMENDED:

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ABSTRACT

Systematics of the tundra hare (Lepus othus Merriam) of western Alaska is treated based on examination of all major collections in North America. Natural history data were collected on the Clarence Rhode National Wildlife Refuge in 1973.

The estimated average growth rate for juvenile hares is 37.2 gm/day over a 102-day growth period from a birth weight of 100 gm to a minimum adult weight of 3900 gm. The single annual litter averages 6.3 (N=10). The conception period (13 to 29 April) and parturition period (29 May to 14 June) were determined from estimated embryo ages. Prenatal loss, known range, food habits, and predation are discussed.

The tundra hare exhibits a latitudinal size cline (Bergmann's Rule), therefore subspecies are not recognized.

Lepus othus is considered a distinct species and not conspecific with Lepus arcticus or Lepus timidus based on morphological characteristics and geographic location.

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INTRODUCTION

In recent years there has been increased interest in wildlife species that are threatened, rare, or whose status remains undetermined. This concern has been precipitated by declines in wildlife populations caused by pesticides, pollution, loss of habitat, and exploitation by man, and has resulted in an increased amount of research being conducted on these species.

It is important that we study species of undetermined status to ascertain if they are threatened or endangered. The tundra hare (*Lepus othus* Merriam) of western Alaska is one of these "undetermined status" species and is probably one of the least known mammals in North America. This thesis is an attempt to provide basic life history information and to clarify the systematic status.

The tundra hare was described by C. Hart Merriam March 14, 1900 as two species: *Lepus othus*, Alaska tundra hare, and *Lepus proadromous*, Alaska peninsula hare. Howell (1936) considered the two conspecific and designated the two subspecies as *Lepus othus othus* and *Lepus othus proadromous*. The species has been considered by some workers to be synonymous with *Lepus arcticus* of Canada or *Lepus timidus* of Siberia (Ellerman and Morrison-Scott 1951, Hall and Kelson 1959, Jones *et al.* 1973, Rausch 1963).

Only a small amount of literature is available on the tundra hare and the majority of it is anecdotal. Papers discussing the tundra hare include two taxonomic papers (Howell 1936, Nelson 1909), a note on finding a litter and growth of a captive juvenile (Walkinshaw 1947), a literature review of food habits (Hansen and Flinders 1969), distributional notes (Bailey and Hendee 1926, Bee and Hall 1956, Burns 1964, Murie 1959, Nelson and True 1887, Osgood 1900, 1904, Quay 1951, Rausch 1951, 1953, Shiller and Rausch 1956), and popular articles or books (Cahalane 1947, Dufresne 1946, Pruitt 1960, Rue 1968). A large proportion of the life history information published for the tundra hare has been inferred from available information on the Canadian arctic hare.

METHODS

Study Areas

Field research was conducted on two study areas near the Chevak-Hooper Bay area on the Yukon-Kuskokwim Delta in western Alaska (Fig. 1) from 3 May to 17 August and 24 to 29 November 1973. This location was selected because (1) tundra hares had been increasing there during the previous 3 years (P. G. Mickelson, personal communication), (2) data were available from specimens that had been collected in the area, and (3) logistic support was available from Clarence Rhode National Wildlife Refuge personnel.

The major study area was located along the north bank of the Kashunuk River, from its mouth upriver 29 km to Onumtuk Slough, and was 1.5 to 5 km wide. Also, a 1.5 km^2 area around Old Chevak was included. The second study area was located along the south side of Kokechik Bay and was 1.5 to 3 km wide. It extended from the base of Panowat Spit east to the mouth of the Kolomak River. It also included the southeast edge of Kikuktok Mountain along the Kolomak River.

Vegetation

Three major habitat types are used in the vegetation classification: (1) sedge flats or wet meadows, located along rivers, sloughs, pond edges, tidal flats, and on low areas 0.6 meter or less above the mean

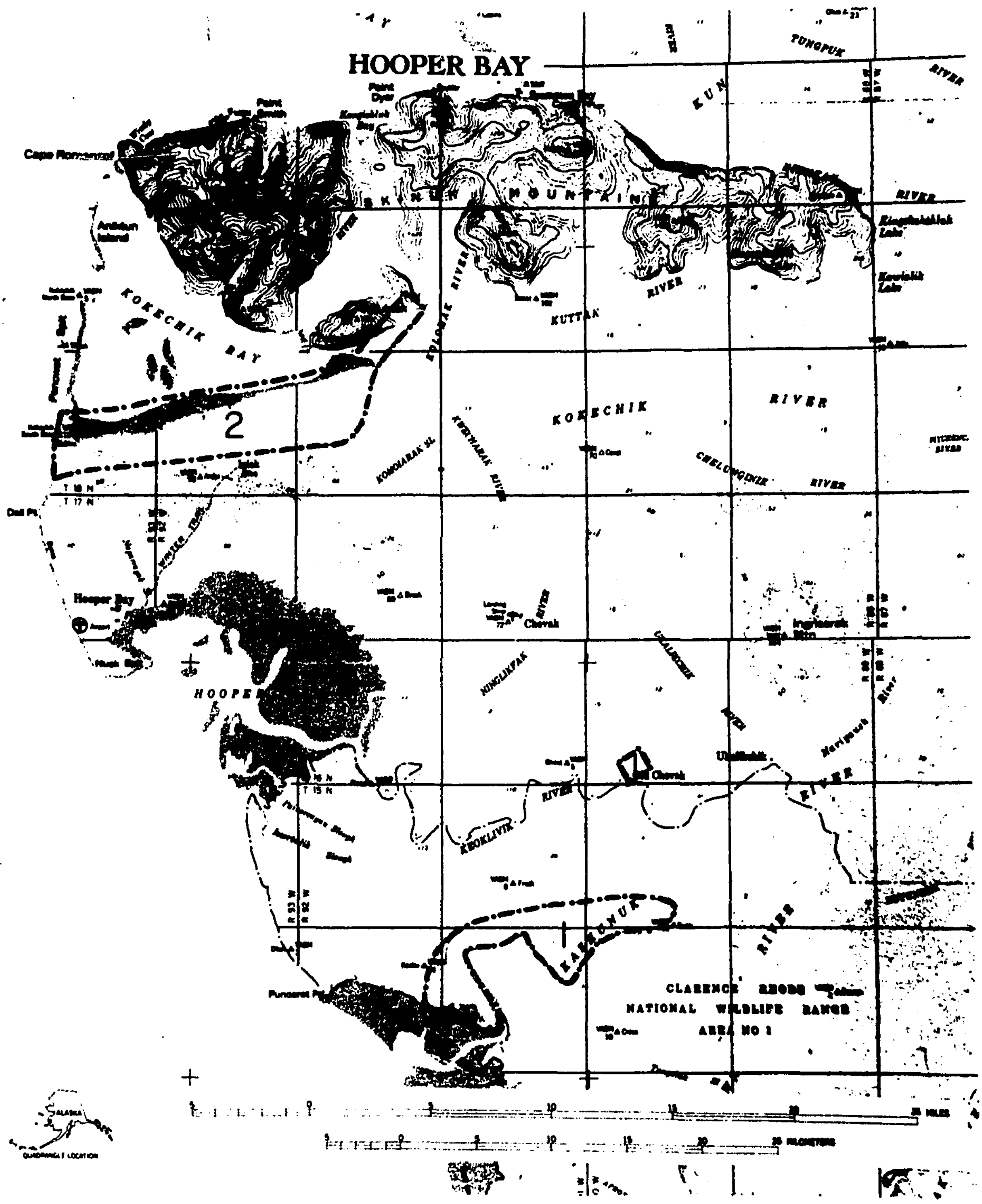


Figure 1. Map of the general area with the study areas outlined.

high tide line; (2) heath or upland tundra, located on pingo tops, bluffs, hillsides, and dry areas 1 meter or more above mean high tide line; (3) shrub zone, located in a narrow band between the wet meadow and upland tundra along the base of the Askinuk Mountains. These are modifications or combinations of habitat types described by Mickelson (1973), Holmes and Black (1973), and Eisenhauer *et al*. (1971). The predominant plant species in these habitat types are: (1) *Carex* spp., *Elymus arenarius*, *Potentilla egedii*, and *Poa eminens*; (2) *Empetrum nigrum*, *Salix* spp., *Ledum decumbens*, *Betula nana*, and lichens; (3) *Salix* spp., *Alnus crispa*, and *Dryopteris*. Table 1 shows the predominant, major, or characteristic plants that were found in the general area by Mickelson (1973), Holmes and Black (1973) and Eisenhauer *et al*. (1971). Wet meadow and upland tundra habitats are found on the major study area and all three habitat types occur on the second study area. Approximately 50% of the study areas consists of sloughs or ponds. The two study areas are considered to be representative of the vegetation and topography of the coastal delta area of western Alaska.

Weather

Weather records from Cape Romansoff weather station were used to determine the following weather parameters on a monthly basis: mean temperature, total precipitation, and maximum depth of snow on the ground. This was done for the study year (November 1972 to October 1973) and for a yearly average (1959-1972). The temperature and precipitation are shown as climographs (Fig. 2) and the snow depths are shown in a graph (Fig. 3).

Table 1. Predominant plant species listed by habitat type. The plant species in each column are the species listed by the authors given.

	Mickelson (1973)[1]	Eisenhauer *et al*. (1971)[2]	Holmes and Black (1973)[3]
Wet Meadow	*Carex rariflora*	*Elymus arenarius* (M)	*Carex rariflora*
	C. mackenziei	*Carex rariflora* (V)	*C. aquatilis*
	Poa eminens	*C. saxatilis* (V)	*Elymus arenarius*
	Elymus arenarius	*Potentilla egedii* (M)	*Poa arctica*
	Eriophorum angustifolium	*Salix ovalifolia* ? (M)	*Sphagnum* spp.
		Calamagrostis canadensis (V)	*Eriophorum* spp.
		Rubus chamaemorus (V)	*Hippurus vulgaris*
		Parnassia palustris (V)	
		Lingusticum scoticum (V)	
		Chrysanthemum arcticum (V)	
Upland Tundra	*Sphagnum* spp.	*Empetrum nigrum* (M)	*Salix* sp.
	Empetrum nigrum	*Salix arctica* ? (V)	*Betula nana*
	Ledum decumbens	*Betula nana* (V)	*Empetrum nigrum*
	Salix ovalifolia	*Rubus chamaemorus* (V)	*Ledum groenlandicum*
	Betula nana	*Ledum decumbens* (V)	*Vaccinium vitis-idaea*
	Lichens	*Calamagrostis canadensis* (V)	*Vaccinium parviflorum*
		Lingusticum scoticum (V)	*Pedicularis* sp.
		Petasites frigidus (V)	*Potentilla* sp.
		Lichens	*Anemone* sp.
			Lichens
Shrub Zone			*Salix* sp.
			Alnus crispa
			Dryopteris

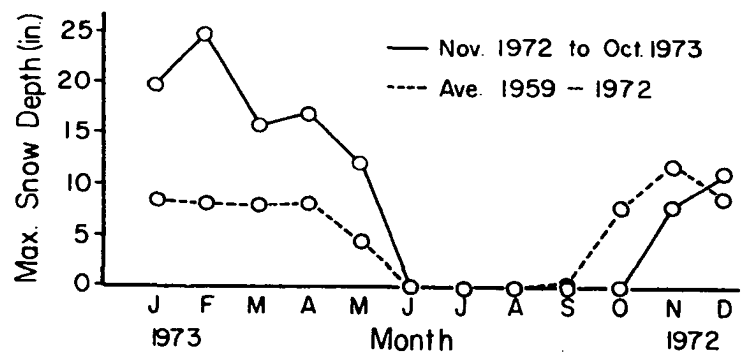
[1]These were given as the predominant plants.

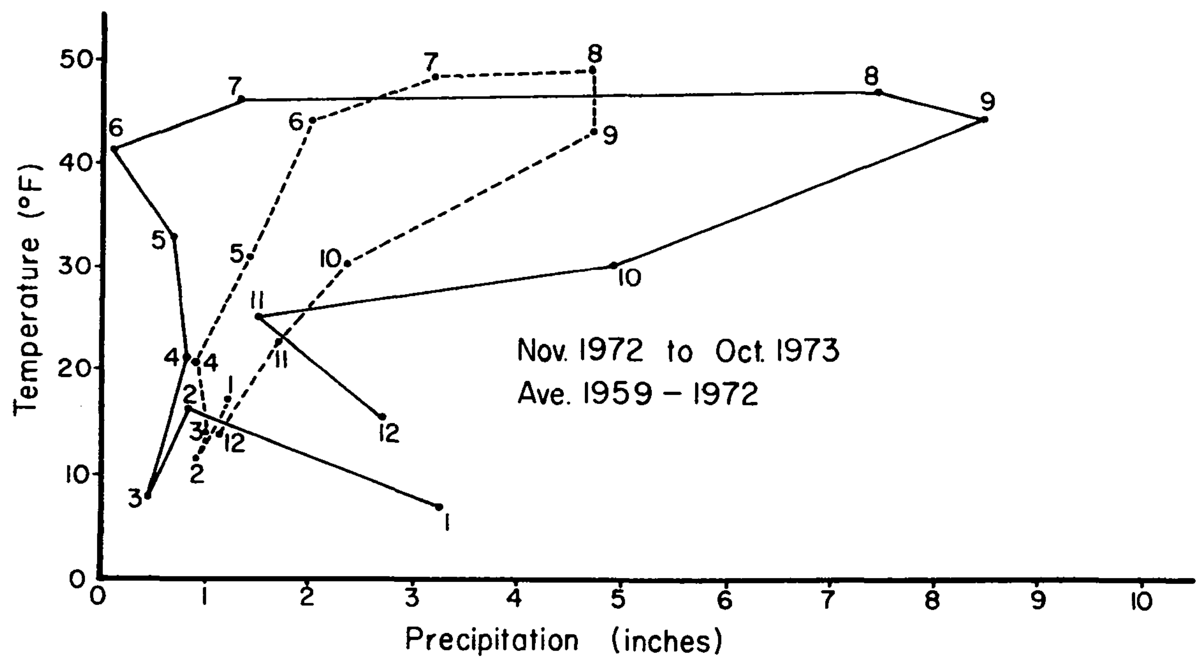
[2]These plants were given as major (M) or very common (V) species and ? indicates tentative identification.

[3]These plants were given as the dominant or primary species.

Figure 3. Maximum monthly snow depth.

Figure 2. Climographs showing temperature and precipitation.


Max. Snow Depth (in.)
25
20
15
10
5
0
Nov. 1972 to Oct. 1973
Ave. 1959 – 1972
J F M A M J J A S O N D
1973
Month
1972


Temperature (°F)
50
40
30
20
10
0
Precipitation (inches)
0 1 2 3 4 5 6 7 8 9 10
Nov. 1972 to Oct. 1973
Ave. 1959 – 1972

Field Methods

The purpose of the field research was to gather basic life history information. Data were collected in the field by: (1) surveying the study areas for the presence of tundra hares, droppings, tracks or feeding signs; (2) collecting tundra hares; and (3) recording observations of tundra hares that were made by myself and other biologists working in the same areas. Also, to supplement the data I collected, all available tundra hare information was compiled that had been collected by P. Mickelson, C. Dau and others during their studies of waterfowl on or near the study areas.

The study areas were surveyed from a snow machine in May and November 1973 when the snow cover was adequate for travel. At all other times the surveys were conducted on foot. A boat was used within each study area for travel between camps and the field. An airplane was used for travel between the two study areas.

Tundra hares were collected during the period 6 May to 17 August 1973 by shooting with a .22 caliber rifle fitted with a 4x scope. Hares were processed within 1 to 4 hours after being collected, by first taking the following measurements: weight, total length, hind foot length, and length of ear from notch. Secondly, the following items were retained from each specimen: skin, skull, femur, reproductive tract, stomach contents, and intestinal contents. The skin, skull, and femur were cleaned and dried. The other items were individually preserved in 10% formalin.

Observations of hares were recorded by noting the location, date, and behavior of the hares. Other biologists conducting waterfowl research on the same areas were requested to record the same information.

Data on tundra hares that had been collected prior to my study were obtained by checking files at Clarence Rhode National Wildlife Refuge Headquarters and by interviewing biologists that had conducted waterfowl research on the areas or by reading their reports.

Laboratory Methods

Specimen material collected in the field study was analyzed in the laboratory to obtain the maximum amount of information. Skeletal material was cleaned in three steps: (1) dermestid beetles, (2) washing with enzyme detergent in hot water, and (3) bleaching with hydrogen peroxide. The following methods were used in the laboratory analyses.

Age Determination

Examination of epiphyseal closure of the femur was the primary technique used to determine age, as it has been shown to be a reliable method in other species of hares; for example, *Lepus californicus* (Lechleitner 1959, Tiemeier 1965), *Lepus townsendii* (Bear and Hansen 1966, James and Seabloom 1969a, 1969b), *Lepus europaeus* (Flux 1967), and *Lepus timidus* (Flux 1970, Walhovd 1965). The second technique utilized to determine age was the degree of development of the anterior supraorbital process of the skull, which has been used on *Lepus arcticus* (Manning and Macpherson 1958) and *Lepus timidus* (Walhovd 1965). This technique was verified by checking the degree of epiphyseal closure on those specimens that had femurs available. The second technique was used when only the skull was available.

Growth

Data from all juvenile tundra hares that had been collected were used to develop an approximate weight growth curve and hind foot growth curve. The weight growth curve was obtained by plotting the weight and approximate age in days of each hare and a curve was fitted by hand to these points. The hind foot growth curve was obtained by plotting the hind foot length and approximate age in days of each hare and a curve was fitted by hand to these data points.

Reproduction

After being separated from the reproductive tract, each ovary was measured and then sliced with a scalpel into longitudinal sections approximately 1 mm thick. These sections were examined under a binocular dissecting microscope for corpora lutea and corpora albicantia. The number and maximum diameter of each corpus luteum and the number of corpora albicantia were recorded. Implantation sites on each reproductive tract were counted, and the embryos removed. A crown-rump length measurement was taken on each embryo.

Gestation, Conception, and Parturition

The gestation period was estimated to be 46 days. The estimate was based on the mean of the range of gestation periods reported for the larger hares in the genus *Lepus*. The gestation periods in other species of *Lepus* range from 42-50 days (*Lepus timidus* Flux 1970, *Lepus europaeus* Flux 1967, *Lepus californicus* Haskell and Reynolds 1947, *Lepus townsendii* James and Seabloom 1969b).

Age of the embryos was estimated by comparing the developmental-morphological characteristics to the stages of development outlined by Bookhout (1964) for known-age snowshoe hare embryos. The second step was to convert from the 37-day gestation period to the 46-day gestation period to obtain the estimated prenatal age of the tundra hare embryos. I assumed that embryo development would be similar in both species. This method was used on white-tailed jack rabbits by James and Seabloom (1969b). As a check on this method I plotted the average crown-rump length for each litter against their estimated age to obtain an embryo growth curve. The embryo growth curve was compared to the snowshoe hare known-age embryo growth curve (Bookhout 1964).

Conception and parturition periods of the tundra hare were determined by using the estimated embryo age, date of collection, and 46-day gestation period to calculate the conception and parturition dates for each set of embryos. The range of conception dates was considered to be the conception period and the range of parturition dates was considered to be the parturition period.

Adult females collected after parturition were checked to determine if they were lactating, or showed signs of recent nursing, as manifested by hair being matted and twisted around the teats (Keith *et al*. 1968).

Birth weight was estimated to be 100 gm based on data given by Walkinshaw (1947). He determined the weight of two different young hares to be 104 gm (2 days old) and 140 gm (3 days old).

Parasites

Hares were examined for ectoparasites when collected and the skins were reexamined in the laboratory. The stomach contents and intestinal contents were examined with a binocular dissecting microscope for parasites.

Food Habits

Stomach contents and pellets of 36 tundra hares collected on the Seward Peninsula were examined by Robert A. Pegau, Alaska Department of Fish and Game, Nome, to determine plant species composition. Food items were identified using microanalysis with the cuticle material being compared to known plant material for identification. The percent of relative density of discerned plant fragments was determined by examining 10 slides with 20 fields per slide for each date.

Predation

Potential predators on the study area were golden eagle (*Aquila chrysaetos*), rough-legged hawk (*Buteo lagopus*) (Degerbol and Freuchen 1935), snowy owl (*Nyctea scandiaca*) (Degerbol and Freuchen 1935, Dufresne 1946, Manniche 1910), arctic fox (*Alopex lagopus*) (Degerbol and Freuchen 1935, Dufresne 1946, Manniche 1910, Pedersen 1966, Soper 1944), and red fox (*Vulpes vulpes*) (Dufresne 1946). Predation was evaluated by examining kills, predator scats, raptor castings and nests.

Range

The known or minimum range was determined by plotting locations of known specimens on a map of Alaska.

Morphology and Systematics

Computer analysis

The following computer programs (Dixon 1970) were used in the analyses of the data.

1. BMD 01D - Simple Data Description - Revised 5 January 1971, Health Sciences Computing Facility, UCLA. This program was used to obtain the following for each measurement: mean, standard deviation, standard error of the mean, and the range.

2. BMD 05M - Discriminant Analysis - Revised 9 June 1966, Health Sciences Computing Facility, UCLA. This program was used to obtain multiple discriminant analyses and Mahalanobis D values.

3. BMD 07M - Stepwise Discriminant Analysis - Revised 29 July 1968, Health Sciences Computing Facility, UCLA. This program was used to obtain stepwise multiple discriminant analyses and canonical variate analyses. It was also used to determine the best skull measurements to utilize in the systematic comparisons.

Morphological Variation

Body and skull measurements of three populations of *Lepus othus* (LOI - Southern, LOII - Central, LOIII - Northern) were compared to determine intraspecific variation and to check for latitudinal size cline (Fig. 4). The measurements of males and females were also compared to check for sexual dimorphism.

Systematics

An effort was made to examine all available specimens of *Lepus othus* so the complete range of variation would be included (Appendix 1). The following data were recorded for each specimen, if available: weight, total length, tail length, hind foot length, length of ear from notch, 24 skull measurements (Appendix 2), and all other information. The

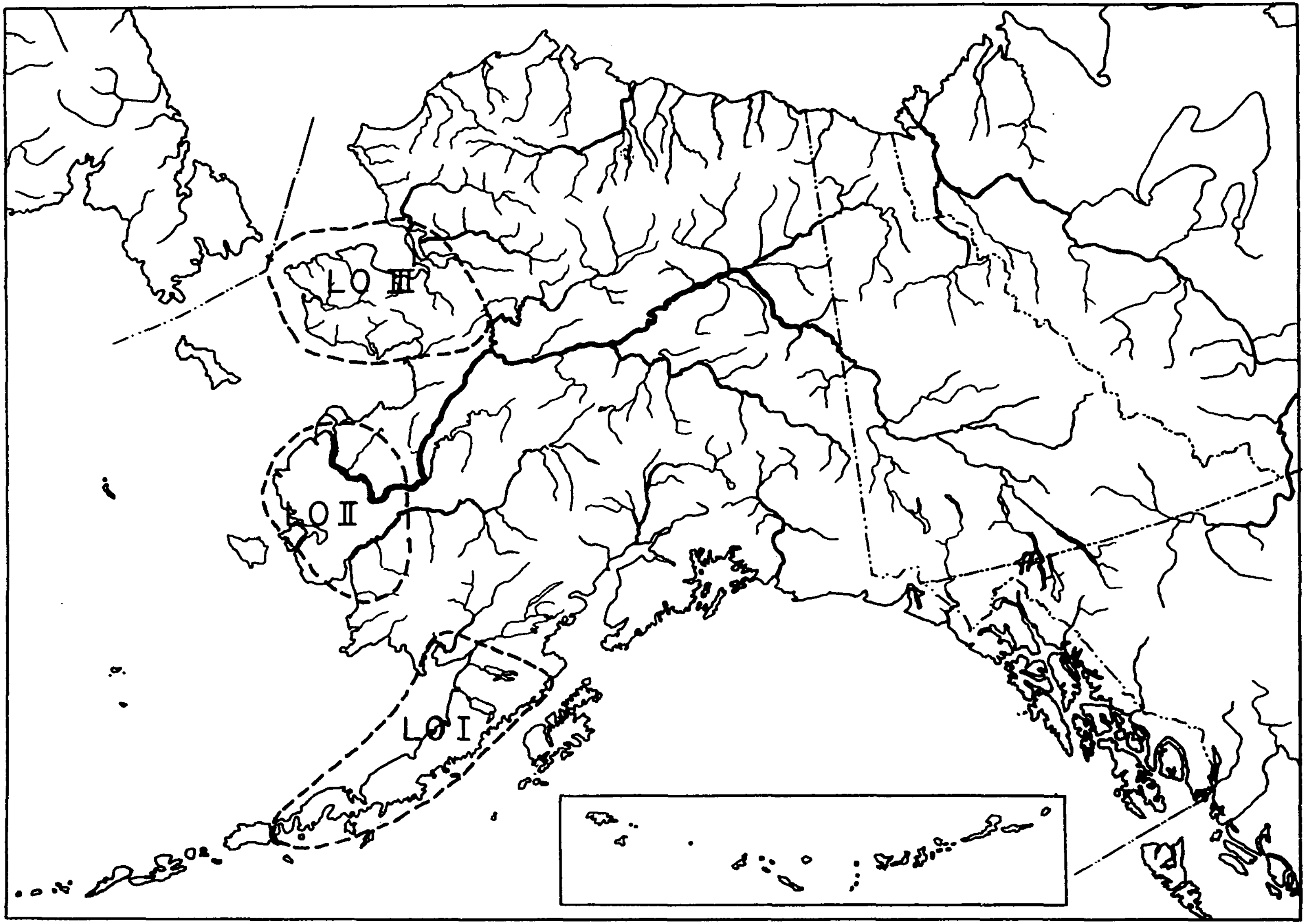


Figure 4. Populations of Lepus othus that were compared to determine intraspecific variation.

same data were recorded for specimens of the Canadian arctic hare (*Lepus arcticus*), Siberian snow hare (*Lepus timidus*), and white-tailed jack rabbit (*Lepus townsendii*). *Lepus arcticus* and *Lepus timidus* were used in the specific comparison because they have been considered to be conspecific with *Lepus othus* by some authors (Ellerman and Morrison-Scott 1951, Hall and Kelson 1959, Jones *et al*. 1973, Rausch 1963). *Lepus townsendii* was used to obtain a minimum Generalized Mahalanobis Distance (D). *Lepus townsendii* was used because it is an accepted species and it is clearly not a northern (arctic) hare.

The body measurements were used only for size comparison because nutritional aspects could mask specific differences or show differences that were only nutritional. Only adult specimens were used in intra- and interspecific analyses. The three populations of *Lepus othus* were compared by the following methods: (1) a discriminant analysis was performed for each population pair combination to obtain Mahalanobis D^2 values to determine statistical significance; (2) Generalized Distance (D) was found for each population pair and plotted; and (3) discriminant multipliers were obtained for each population pair. The stepwise discriminant analysis was used to determine the best skull measurements to use in the species comparison. The best seven skull measurements were then used to obtain the following: (1) four species group multiple discriminant analysis; (2) four species canonical variate analysis; (3) a discriminant analysis for each species pair combination to obtain Mahalanobis D^2 values to determine statistical significance; (4) Generalized Distance (D) for each species pair; and (5) discriminant multipliers for each species pair.

Multiple discriminant analysis has been used by Lawrence and Bossert (1967, 1969) in comparison of Canis species, Rohwer and Kilgore (1973) in comparison of interbreeding in Vulpes species, Genoways and Choate (1972) in systematic relationships in shrews, Thaeler (1968) in analysis of hybridization of Thomomys species, and Jolicoeur (1959) for geographical variation in Canis lupus. The combination of multivariate analysis and canonical variate analysis was used by Patton (1973) in an analysis of hybridization in Thomomys species.

Giles (1960) used multivariate analysis, Mahalanobis D^2 statistic and Generalized Distance in an analysis of Canis latrans taxonomy.

Explanation of Generalized Mahalanobis Distance (Rao 1965): Suppose m characteristics are measured in two populations, A and B, giving population means

$$\begin{bmatrix} \bar{X}_{A1} \\ \bar{X}_{A2} \\ \cdot \\ \cdot \\ \cdot \\ \bar{X}_{Am} \end{bmatrix} \quad \text{and} \quad \begin{bmatrix} \bar{X}_{B1} \\ \bar{X}_{B2} \\ \cdot \\ \cdot \\ \cdot \\ \bar{X}_{Bm} \end{bmatrix}$$

The Euclidean (geometric) distance between the two population means is

$$d = \sqrt{(\bar{X}_{A1} - \bar{X}_{B1})^2 + (\bar{X}_{A2} - \bar{X}_{B2})^2 + \cdot \cdot \cdot + (\bar{X}_{Am} - \bar{X}_{Bm})^2} \, ,$$

by the Pythagorean theorem.

The measurements have some natural variability however, and it is logical to require that the contribution a characteristic makes to the distance be inversely proportional to its variance. Assuming all characteristics are uncorrelated, the formula becomes

$$d = \sqrt{\frac{(\bar{X}_{A1} - \bar{X}_{B1})^2}{\sigma_1^2} + \frac{(\bar{X}_{A2} - \bar{X}_{B2})^2}{\sigma_2^2} + \cdot \cdot \cdot + \frac{(\bar{X}_{Am} - \bar{X}_{Bm})^2}{\sigma_3^2}}$$

This is the Generalized Mahalanobis Distance between the two populations when all of the characteristics are uncorrelated. It is a reasonable measure of the biological distance between the two populations, based on the characteristics measured.

In general, however, the characteristics are correlated. Positive correlations will tend to make d larger, while negative correlations will make d smaller. To correct for these spurious effects, d is defined by

$$D = \sqrt{\sum_{i=1}^{m} \sum_{j=1}^{m} a_{ij} (\bar{X}_{Ai} - \bar{X}_{Bi}) (\bar{X}_{Aj} - \bar{X}_{Bj})} \quad .$$

Where the $\{a_{ij}\}$ are elements of the inverse covariance matrix common to both populations. Hence, D (Generalized Mahalanobis Distance) is a reasonable measure of the biological distance between the two populations based on m characteristics and corrected for the variability and inter-correlations of the characteristics. The Generalized Mahalanobis Distance D is a dimensionless number.

RESULTS

Tundra hare observation and collection sites on the two study areas are plotted on Figures 5 and 6. A minimum of 23 different tundra hares were seen in the overall area both on and off the study areas. This number includes the hares that were collected.

Figure 7 shows the stages of epiphyseal closure that were used in the age determination. Figure 8 shows the development of the anterior supraorbital process that was used as a secondary method to determine age.

Growth

The average growth rate of the tundra hare was determined to be 37.2 gm/day. The growth period from a birth weight of 100 gm to a minimum adult weight of 3900 gm was 102 days (Fig. 9). The hind foot attained 95% of average adult size (185 mm) in 16 weeks, a growth rate of 2.57 mm/day (Fig. 10).

Reproduction

Preimplantation loss of 34.6% of the ova and a post implantation loss of 7.7% of the embryos was determined from the examination of three reproductive tracts with embryos (Table 2). All reproductive tracts had preimplantation loss, but only one had post implantation loss with two embryos being resorbed.

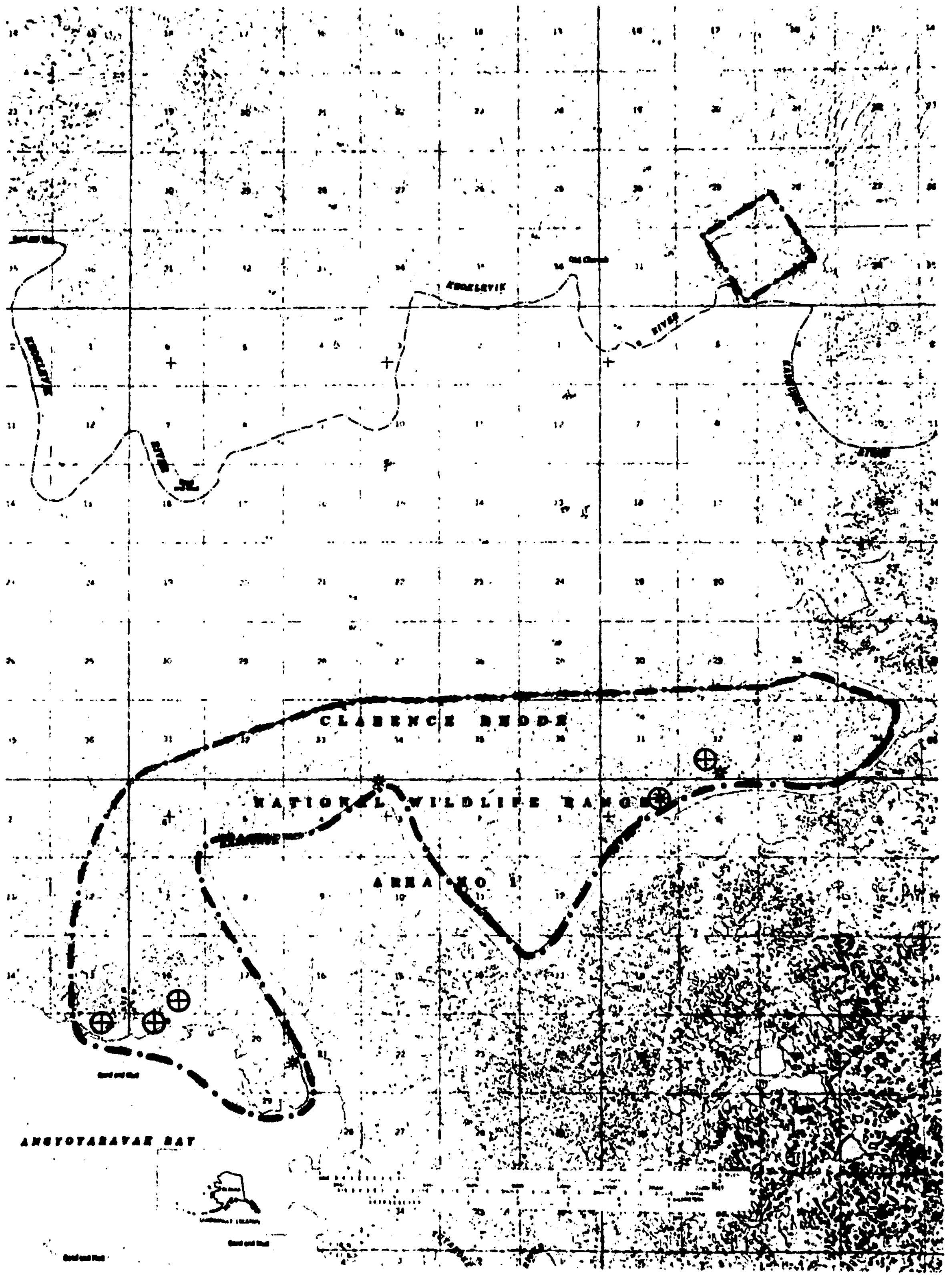


Figure 5. Map of major study area. Collection sites =✱ Observation sites =⊕

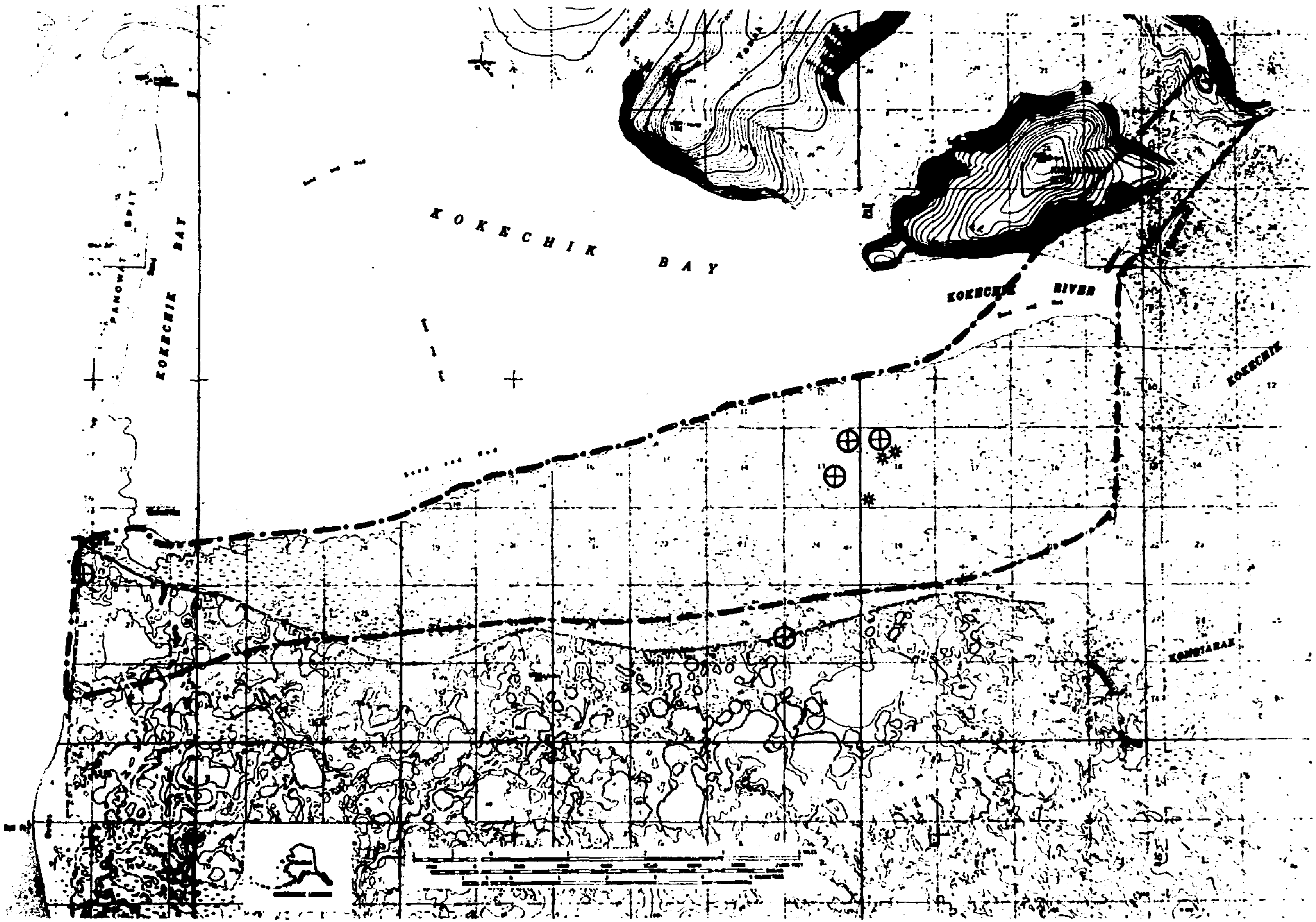


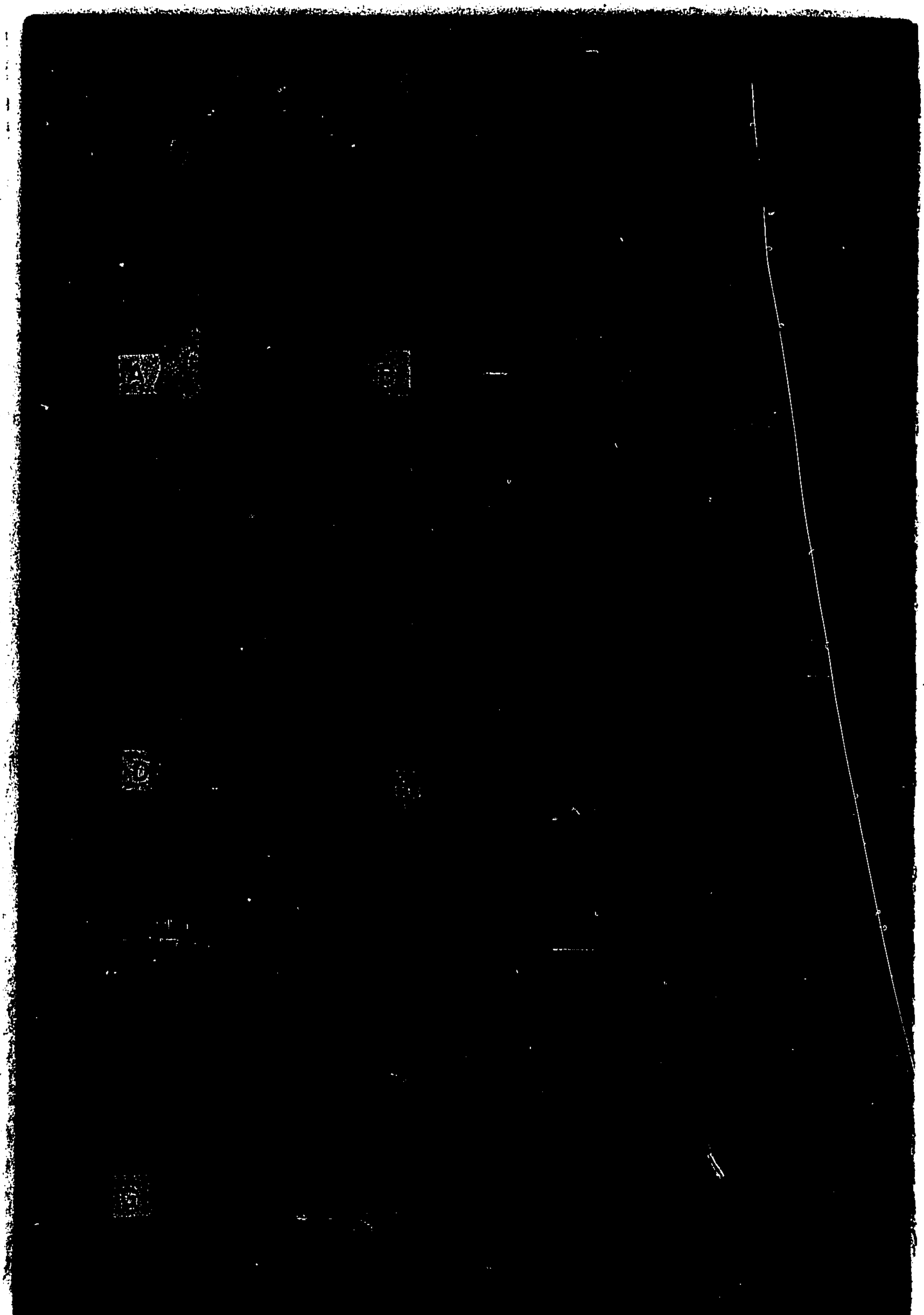
Figure 6. Map of secondary study area. Collection sites =✱ Observation sites =⊕

Figure 7. Stages of epiphyseal closure of the femur of the tundra hare.

A to C are juveniles;

D to I are adults.

Femurs shown match with the skulls shown in Figure 8, with the letters of the two figures being the same for each hare.



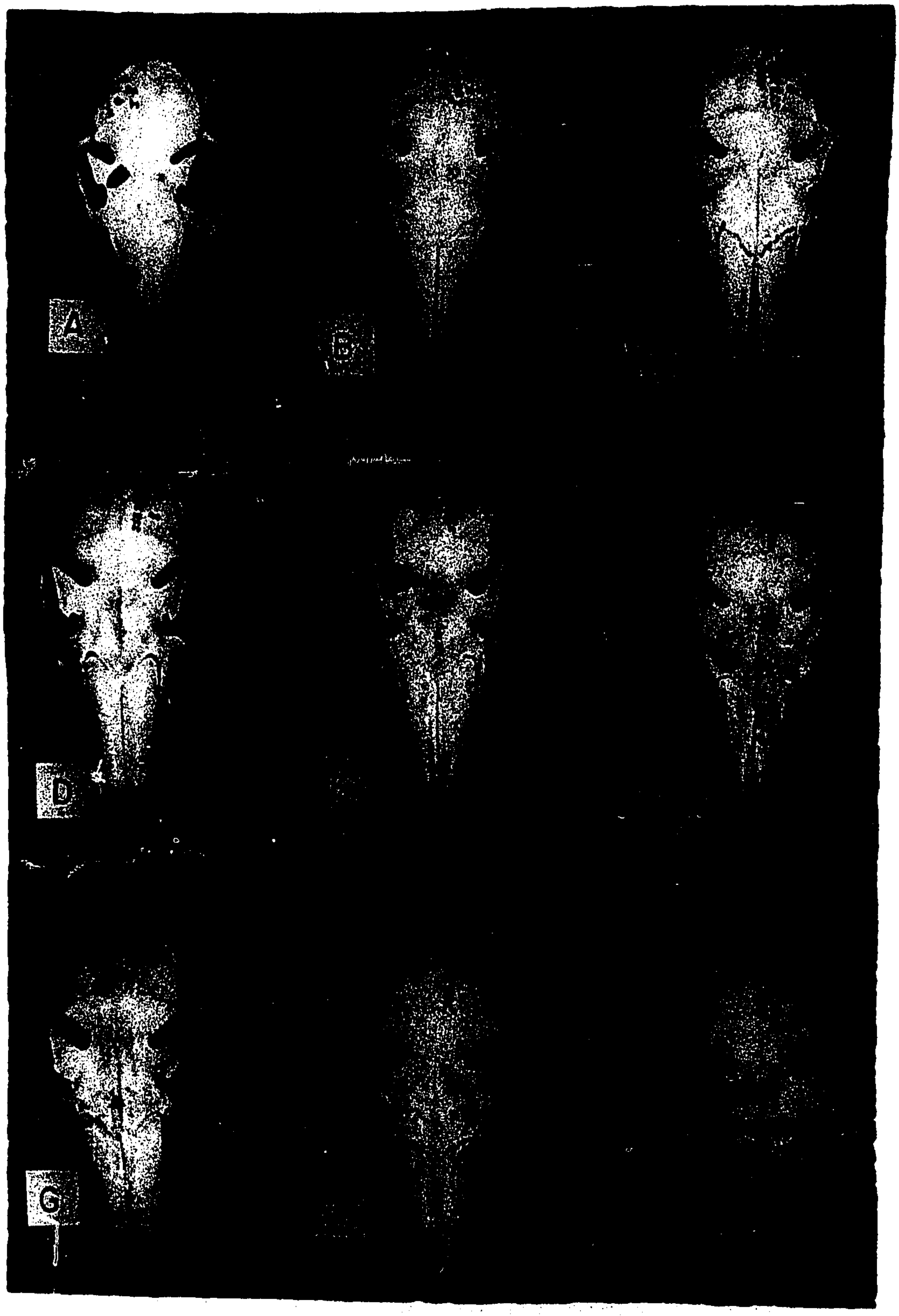


Figure 8. Development of the supraorbital process in tundra hare skulls. A to C are juveniles, D to I are adults.

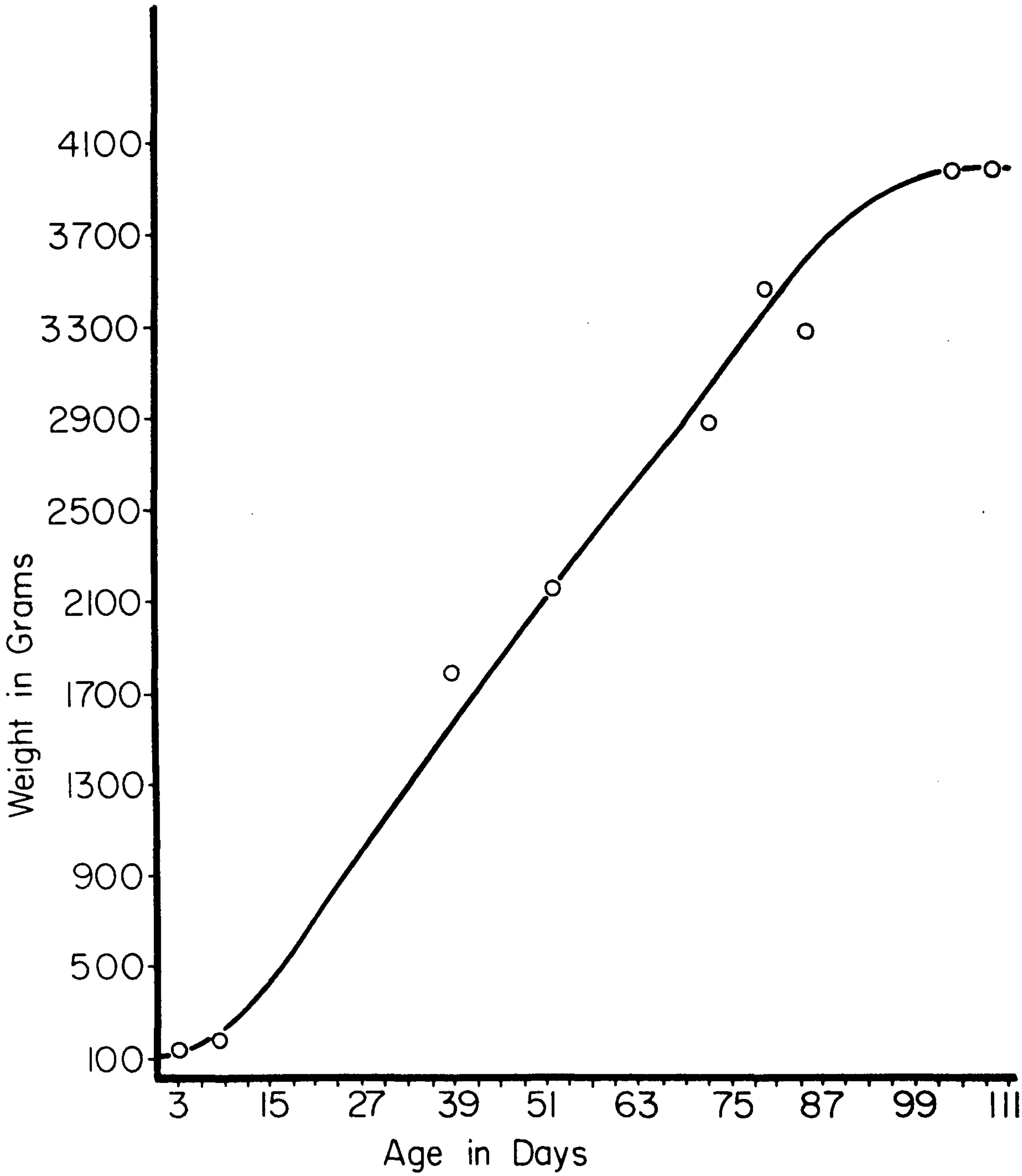


Figure 9. Weight growth curve of the tundra hare.

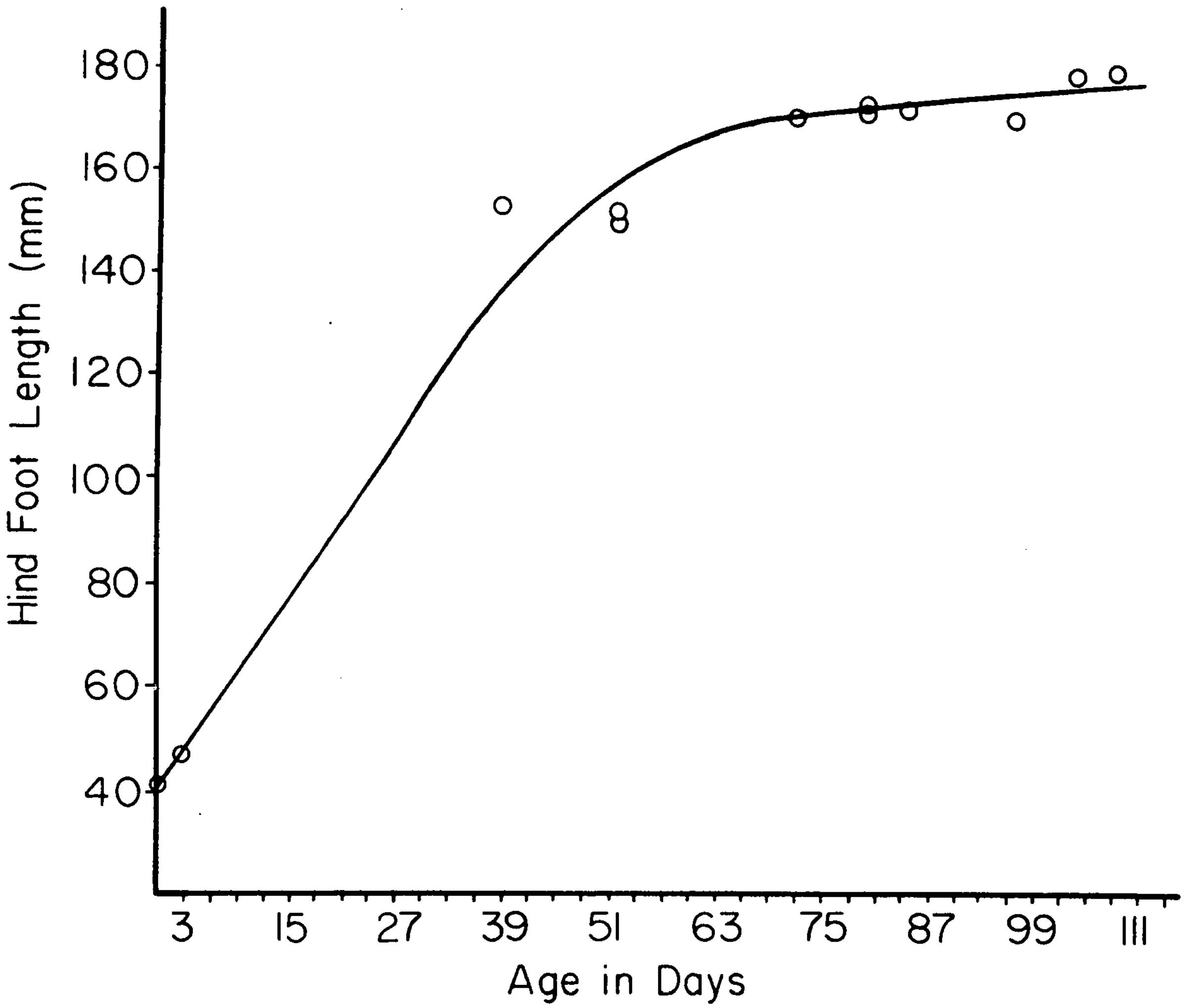


Figure 10. Hind foot growth curve of the tundra hare.

Table 2. Prenatal loss of ova and embryos in tundra hares as determined from examination of corpora lutea, implantation sites, and embryos.

	Hare Number			Total	Average
	2	4	5		
Number of corpora lutea	9	8	9	26	8.7
Number of implantation sites	3	6	8	17	5.7
Number of embryos	3	6	6	15	5.0
Preimplantation loss (%)	66.7	25	11	34.6	
Postimplantation loss (%)	-	-	25	7.7	
Total prenatal loss				42.3	

The average litter size was 6.3 (N=10) with 80% of the litters consisting of six or seven young (Fig. 11).

The estimated gestation period was 46 days. By the methods described on page 11, both the conception period (12-29 April) and the parturition period (28 May to 14 June) were determined to be 18 days in duration (Fig. 12).

The embryo growth curve that I obtained for the tundra hare (Fig. 13) was similar to the known-age embryo growth curve of snowshoe hares (Fig. 14) obtained by Bookhout.

Three adult females that were collected on 22 July 1972, 22 July 1972, and 7 August 1973 (Nos. 82, 10, 9) had well developed mammary glands and showed signs of recent nursing. Juvenile hare (No. 7) which was approximately 2 months old had milk in its stomach.

Parasites

Ectoparasites were not found. The small intestine of an adult female (No. 4) contained 12 trichostrongylid nematodes.

Food Habits

During April and May the diet consists mainly of shrubs with Salix alaxensis and Empetrum nigrum being the most important plant species (Table 3). The Salix material was predominantly woody tissue and the Empetrum was primarily leaves. There were no significant differences found when the diets were compared between months or between sexes. This food habit information was obtained from hares taken on the Seward Peninsula. My observations indicate that the hares on the Yukon-Kuskokwim Delta had similar food habits. The hares were observed

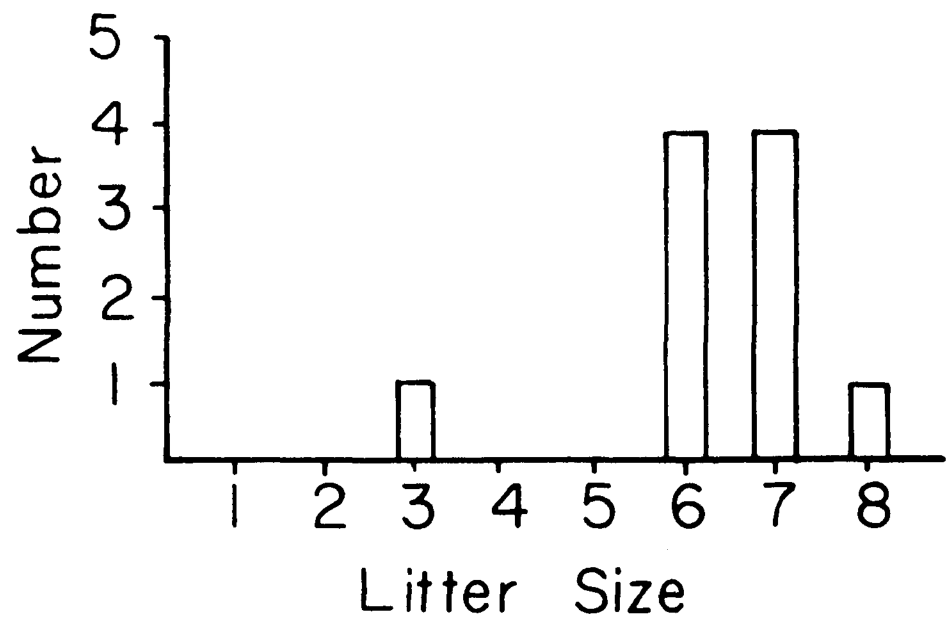


Figure 11. Tundra hare litter size, from counts of embryos, uterine scars, and one newborn litter.

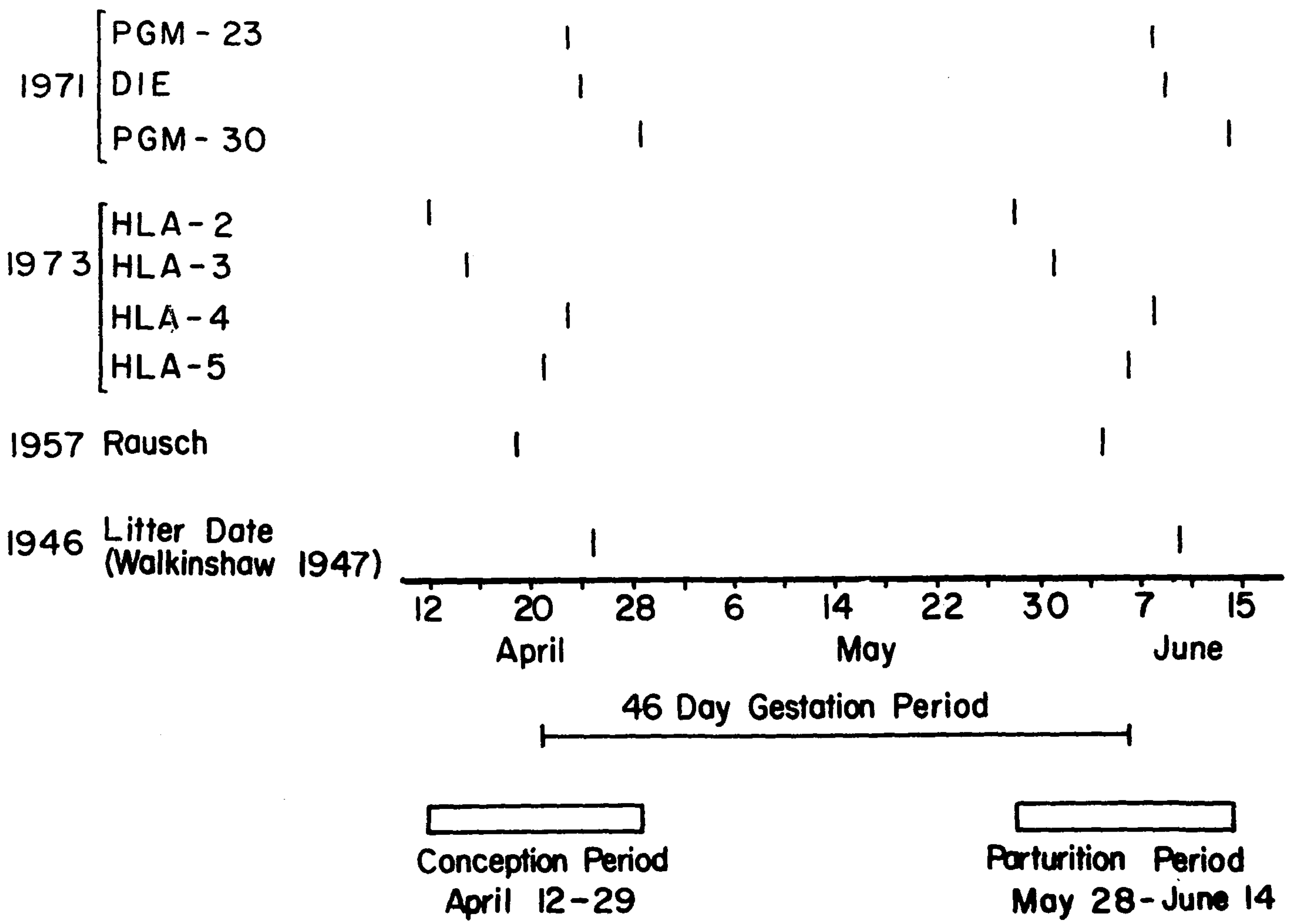


Figure 12. Estimated conception and parturition periods from estimated ages of collected embryos and one newborn litter.

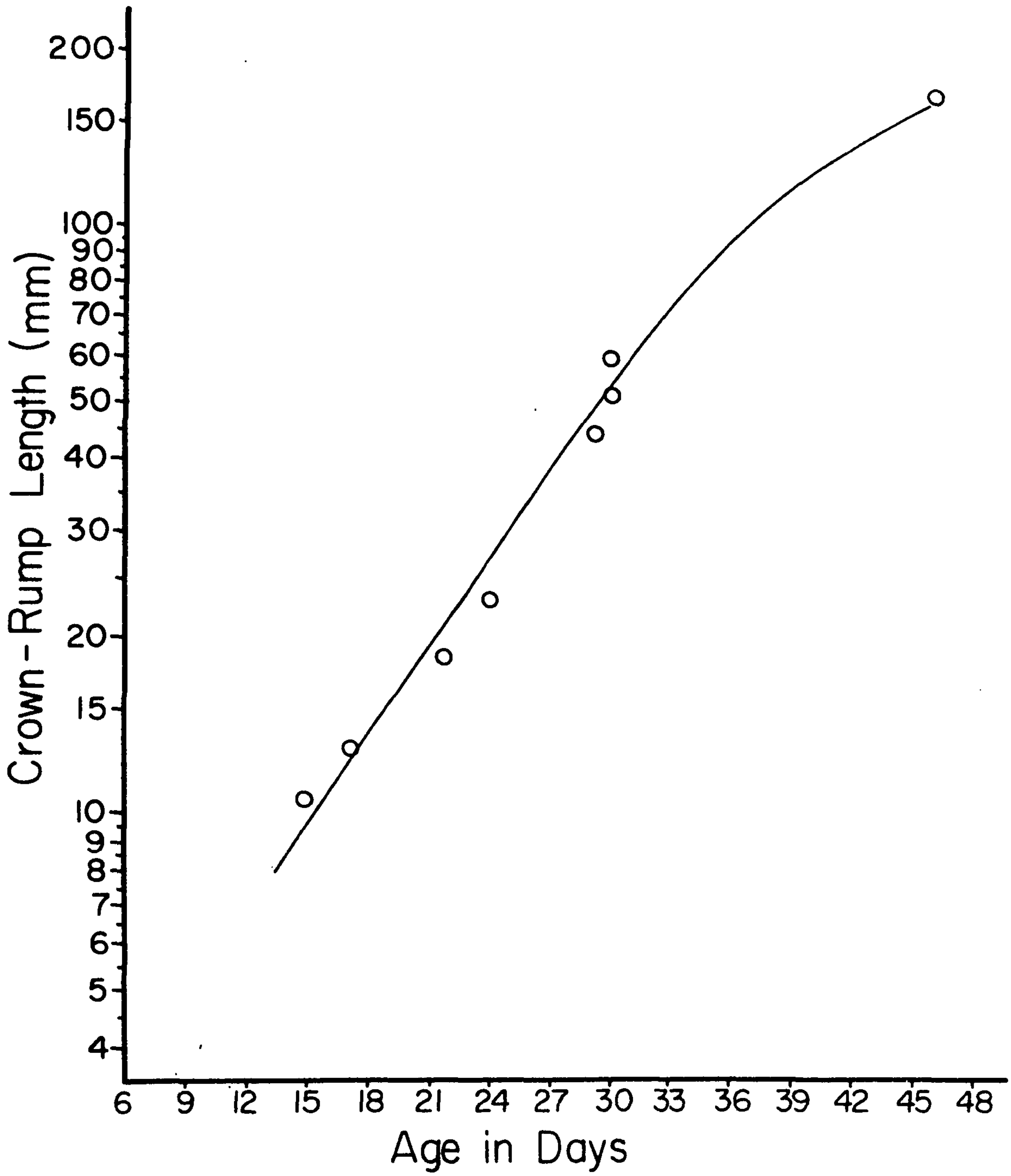


Figure 13. Estimated tundra hare embryo growth curve.

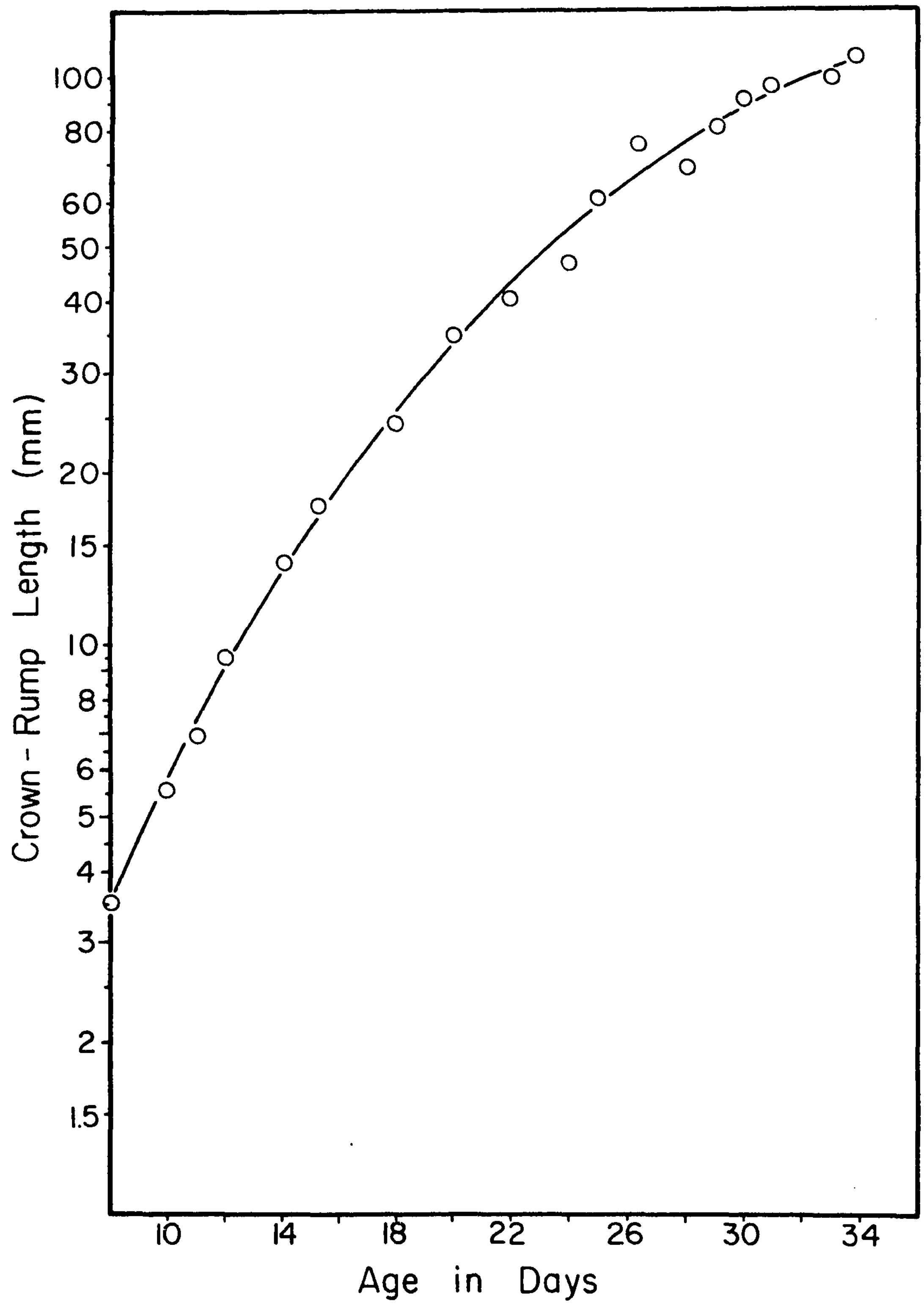


Figure 14. Known-age snowshoe hare embryo growth curve (Bookhout 1964).

Table 3. Relative density of discerned plant fragments in percent from combined stomach contents and fecal pellets from tundra hares (R. Pegau, unpublished data).

Plant Species	Combined Samples				
	AH-1-71 Male stomach Arctic River May 1971	AH-2-71 Male fecal Arctic River May 1971	AH-3-71 Female stomach Arctic River May 1971	AH-4-71 Female fecal Arctic River May 1971	AH-5-71 Male stomach and fecal Serpentine R. May 1971
Betula nana				0.23	
Dryas octopetala	0.39			0.46	
Empetrum nigrum	7.84	6.80	27.39	15.03	67.19
Salix alaxensis	90.21	93.00	72.41	83.82	31.67
Salix pulchra	1.57				
Vaccinium vitis-idaea				0.23	
Eriophorum vaginatum				0.23	
Equisetum sp.		0.20			
Hierochloe alpina				0.91	
Lichen					
Cetraria sp.				0.23	

Table 3, continued.

Plant Species	Combined samples: AH-6-71 Female stomach and fecal Serpentine R. April 1971	Combined samples: AH-7-71 Female stomach and fecal Kuzitrin R. April 1971	Averages: April	Averages: May	Averages: Overall	Averages: Males	Averages: Females
Betula nana				0.05	0.03		0.06
Dryas octopetala		0.69	0.35	0.17	0.22	0.13	0.29
Empetrum nigrum	49.15	1.20	25.18	24.85	24.94	27.28	23.19
Salix alaxensis	50.54	98.11	74.33	74.22	74.25	71.63	76.22
Salix pulchra				0.31	0.22	0.52	
Vaccinium vitis-idaea	0.31		0.16	0.05	0.08		0.14
Eriophorum vaginatum				0.05	0.03	0.07	0.06
Equisetum sp.				0.04	0.03		
Hierochloe alpina				0.18	0.13		0.23
Lichen							
Cetraria sp.				0.05	0.03		0.06

feeding on Empetrum and fecal material was found in areas of low Salix that had been severely browsed.

Predation

The remains of two tundra hares were found on the secondary study area. One was an adult killed during the winter and the other was a juvenile killed in late July. Examination of 98 raptor castings and 43 fox scats showed the following items to contain tundra hare remains: one golden eagle casting, one small raptor casting, and one fox scat.

Range

The known range of the tundra hare was determined to include most of the west coast of Alaska. It extends from the Selawik-Kotzebue area to the Cold Bay area and includes all of the Seward Peninsula and most of the Alaska Peninsula (Fig. 15).

Morphological Variation

The three populations of *Lepus othus* exhibit a latitudinal size cline in the means of the hind foot length and 15 skull measurements (Fig. 16). The size cline follows Bergmann's Rule with body size and latitude having a positive correlation (Table 4).

Body and skull measurements were not found to exhibit sexual dimorphism. Discriminant analysis of male and female skull measurements showed that they were not significant ($P>0.25$) and only 61% of the skulls were correctly classified (Table 5).

Variation in the body and skull measurements of the four species compared are shown in Appendix 5 and 6. The general size trend from

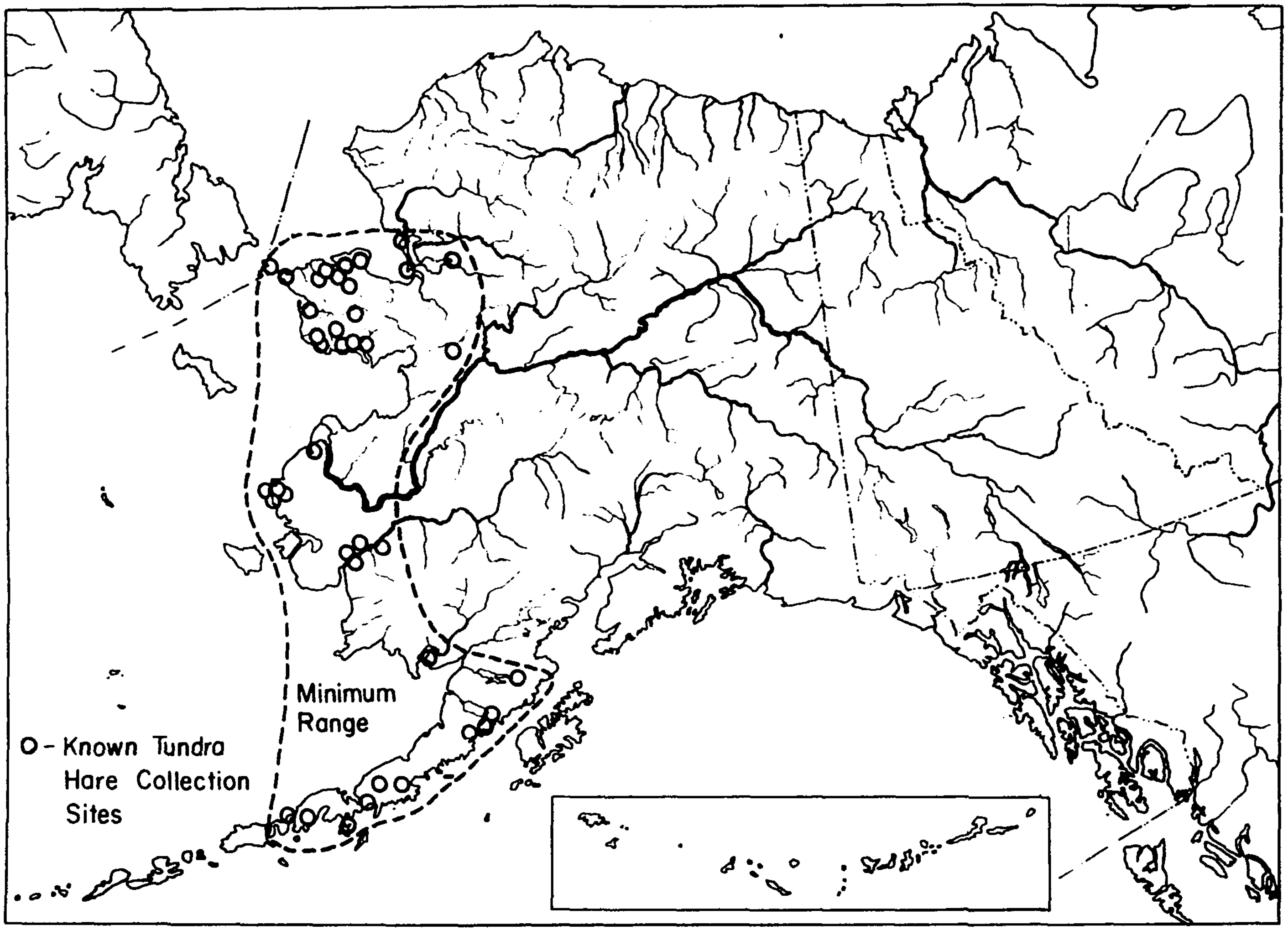


Figure 15. Known range of the tundra hare.

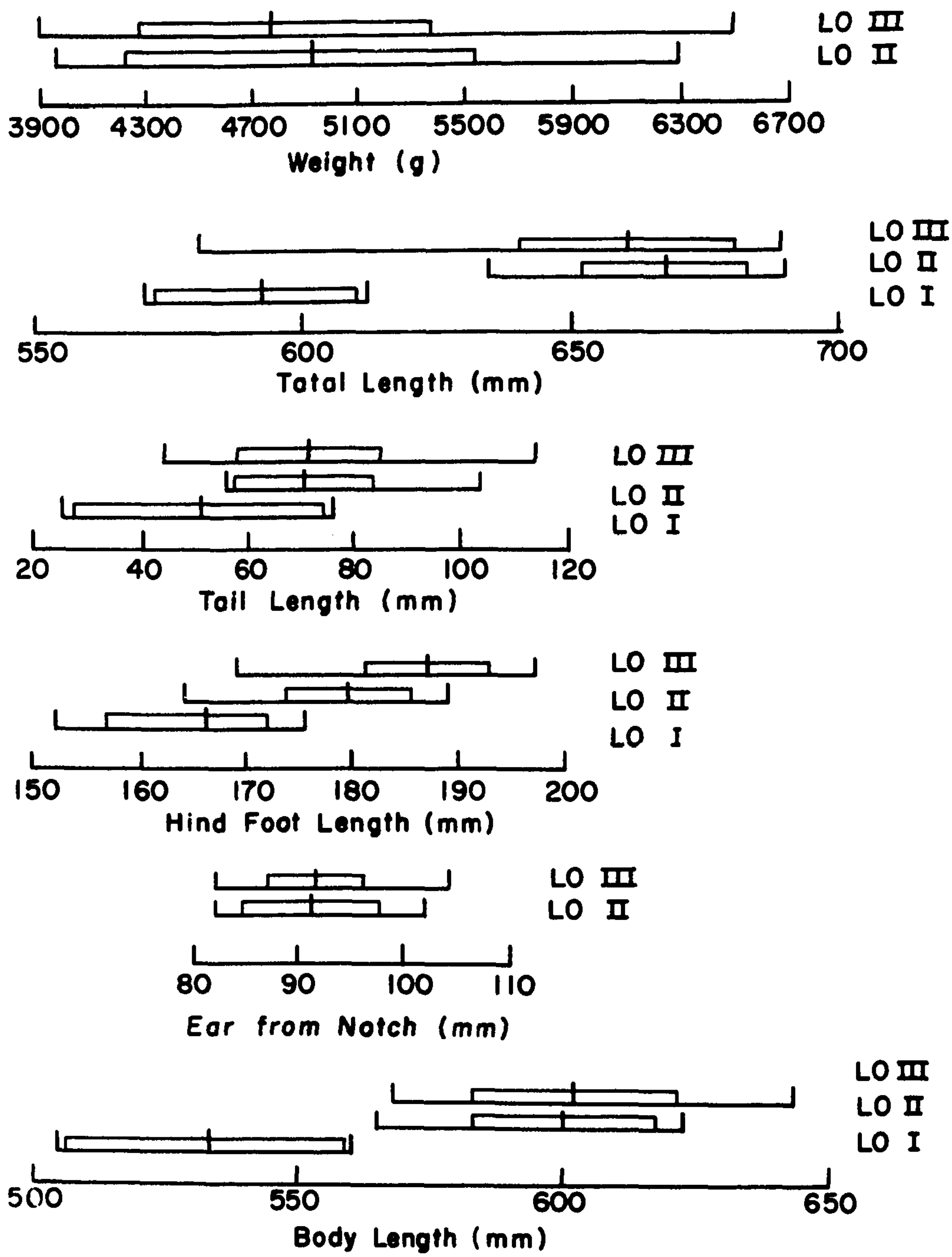


Figure 16. Comparison of the body and skull measurements of the three Alaskan populations of the tundra hare.

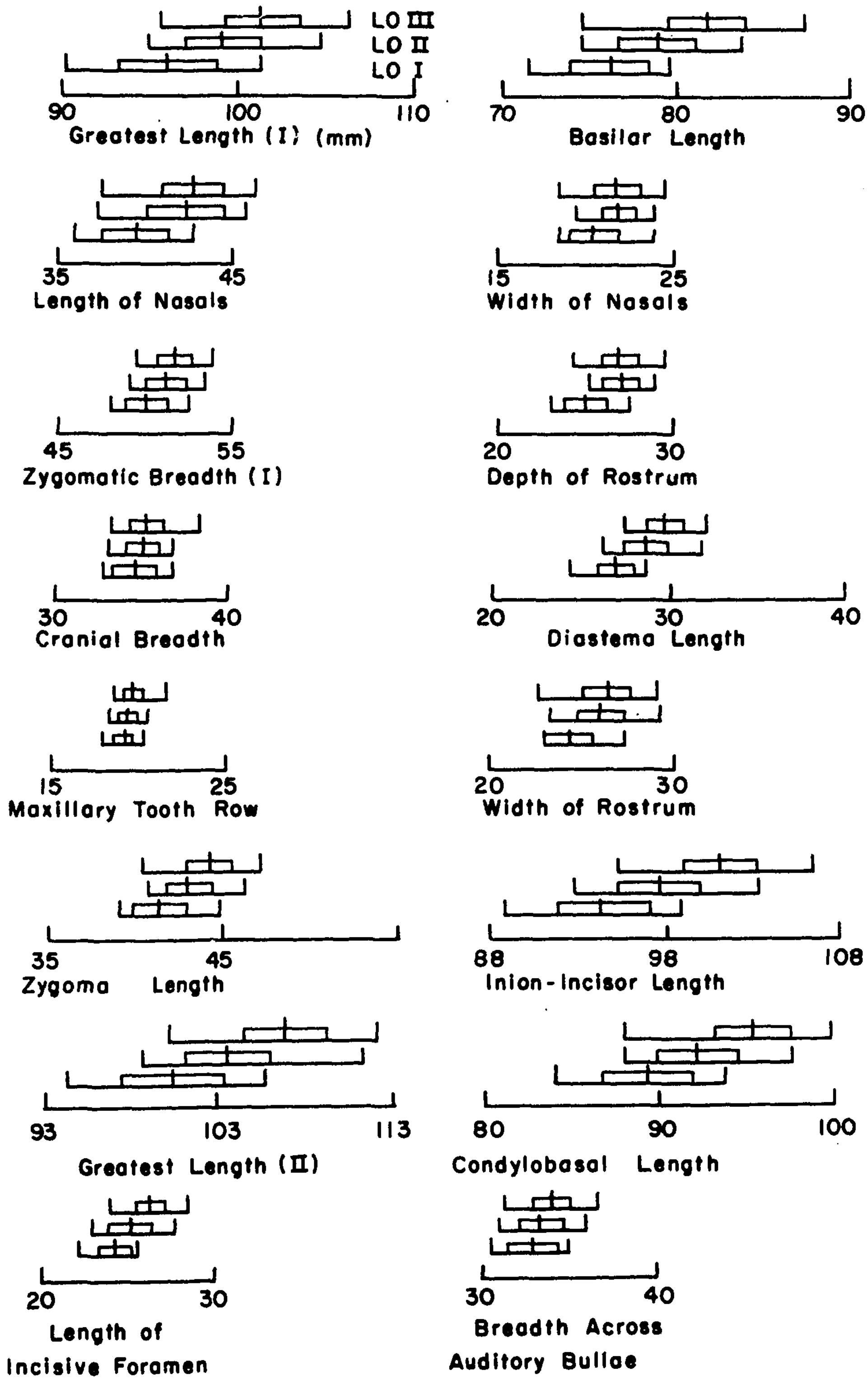
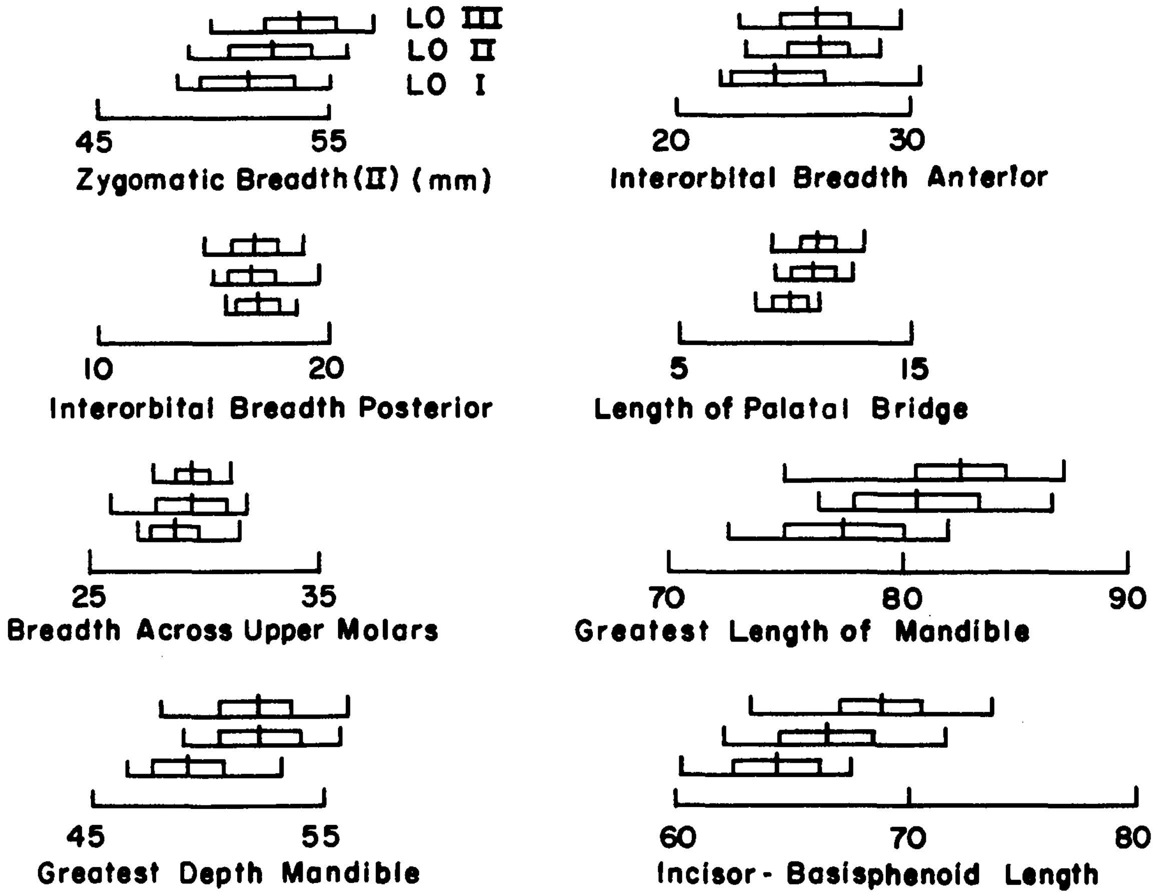

LO III
LO II
LO I
90
100
110
Greatest Length (I) (mm)
70
80
90
Basilar Length
35
45
Length of Nasals
15
25
Width of Nasals
45
55
Zygomatic Breadth (I)
20
30
Depth of Rostrum
30
40
Cranial Breadth
20
30
40
Diastema Length
15
25
Maxillary Tooth Row
20
30
Width of Rostrum
35
45
Zygoma Length
88
98
108
Inion-Incisor Length
93
103
113
Greatest Length (II)
80
90
100
Condylobasal Length
20
30
Length of Incisive Foramen
30
40
Breadth Across Auditory Bullae

Figure 16, continued.



All length measurements are in mm.

LOIII - Northern Population
LOII - Central Population
LOI - Southern Population

Each horizontal line gives the range, the central vertical line gives the mean, and the box on each side of the mean gives one standard deviation.

Table 4. Correlations of size of body and skull measurements in three *Lepus othus* populations.

Character	Correlation Coefficient (r)	Significance
Hind Foot	0.9994	P<0.001
Body Length	0.9334	P<0.10
Greatest Length (I)	0.9996	P<0.0005
Basilar Length	0.9882	P<0.01
Zygomatic Breadth (I)	0.9950	P<0.005
Cranial Breadth	0.9852	P<0.025
Diastema Length	0.9993	P<0.001
Maxillary Tooth Row	0.9596	P<0.05
Zygoma Length	0.9991	P<0.001
Inion-Incisor Length	0.9902	P<0.01
Greatest Length (II)	0.9916	P<0.01
Condylobasal Length	0.9875	P<0.025
Length of Incisive Foramen	0.9762	P<0.025
Breadth across Auditory Bullae	0.9729	P<0.05
Zygomatic Breadth (II)	0.9784	P<0.025
Greatest Length of Mandible	0.9691	P<0.05
Incisor-Basisphenoid Length	0.9901	P<0.01

Table 5. Classification of tundra hare skulls by sex to determine if the tundra hare shows sexual dimorphism in skull measurements.

	Classification Matrix		
	Males	Females	Total
Males	30	17	47
Females	16	21	37

	Number	Percent
Identified Correctly	51	61
Identified Incorrectly	33	39

Mahalanobis D^2 Value 9.007 Significance $P>0.25$

largest to smallest species was: *Lepus othus*, *Lepus arcticus*, *Lepus timidus*, and *Lepus townsendii*.

Systematics

The maximum Generalized Distance of the three populations of *Lepus othus* was 10.15. Only 78% of the specimens of LOI and LOII and 78% of the specimens of LOII and LOIII were correctly classified in the discriminant analysis of the population pairs. The Mahalanobis D^2 values for all population pair mean were significant ($P<0.005$) (Table 6). The intraspecific variation was attributed to latitudinal size cline.

The Generalized Distance between each pair of the three arctic hare species (12.0 to 17.8) was greater than the minimum Generalized Distance between *Lepus townsendii* and the three arctic hare species (10.3) (Fig. 17). Also, they were greater than the maximum Generalized Distance of *Lepus othus* (10.15).

Mahalanobis D^2 values (Table 7) for all species pair combinations were significant ($P<0.001$) and the multiple discriminant analysis correctly classified 92% of the specimens. The canonical variate analysis (Fig. 18) also separated the species with only a few exceptions.

Table 6. Discriminant multipliers for *Lepus othus* populations.

Character	Discriminant Multipliers		
	LOI vs LOII	LOII vs LOIII	LOI vs LOIII
Greatest Length (I)	-0.482	-0.588	-0.175
Zygomatic Breadth (I)	0.078	-0.137	0.456
Maxillary Tooth Row	1.304	-0.082	-1.188
Zygoma Length	-0.094	-0.131	0.355
Inion-Incisor Length	-0.489	0.720	1.761
Condylobasal Length	0.156	0.412	-0.790
Length of Incisive Foramen	0.282	0.395	1.557
Mean Discriminant Value for:			
LOI	---	48.327	141.810
LOII	-46.726	45.852	---
LOIII	-49.049	---	131.729
Pair	-47.887	47.089	136.769
Mahalanobis D^2 Value	21.166*	61.078**	103.280**

*(P<0.005) Table value for chi square 0.005 with 7 d.f. = 20.278.

**(P<0.001) Table value for chi square 0.001 with 7 d.f. = 24.322.

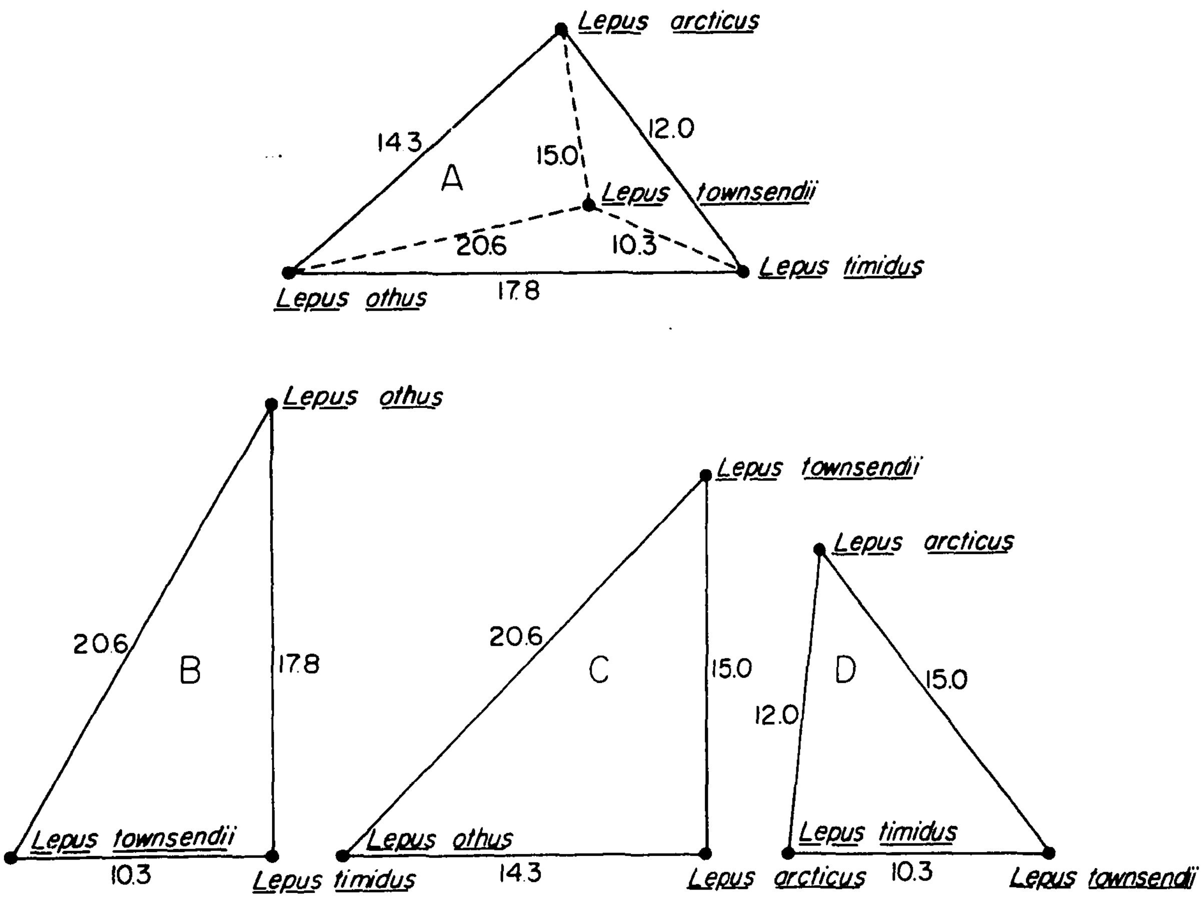


Figure 17. Comparison of Generalized Mahalanobis Distances between <u>Lepus</u> species.

Table 7. Discriminant multipliers for the four Lepus species.

Character	Discriminant Multipliers					
	Lepus othus vs L. arcticus	L. othus vs L. timidus	L. arcticus vs L. timidus	L. othus vs L. townsendii	L. arcticus vs L. townsendii	L. timidus vs L. townsendii
Greatest Length (I)	-1.501	1.526	3.125	1.489	2.145	-0.688
Zygomatic Breadth (I)	0.292	1.065	0.264	4.511	4.038	2.070
Maxillary Tooth Row	3.506	0.684	3.643	4.819	1.374	2.993
Zygoma Length	1.128	0.765	0.506	2.559	0.256	1.307
Inion-Incisor Length	1.655	0.151	-0.881	-4.828	-6.355	-2.206
Condylobasal Length	-1.583	-1.453	-0.926	2.060	4.502	1.415
Length of Incisive Foramen	1.827	0.562	-0.956	-0.583	-5.053	-0.141
Mean Discriminant Value for:						
Lepus othus	45.420	147.303	---	284.765	---	---
Lepus arcticus	34.832	---	215.635	---	125.443	---
Lepus timidus	---	134.332	201.623	---	---	49.200
Lepus townsendii	---	---	---	233.977	90.277	33.830
Pair	40.126	140.817	208.629	259.371	107.860	41.515
Mahalanobis D^2 Value	205.433**	318.793**	144.760**	426.571**	227.735**	107.221**

**(P<0.001) Table value for chi square 0.001 with 7 d.f. = 24.322.

Figure 19. Canonical variate analysis of the four *Lepus* species.

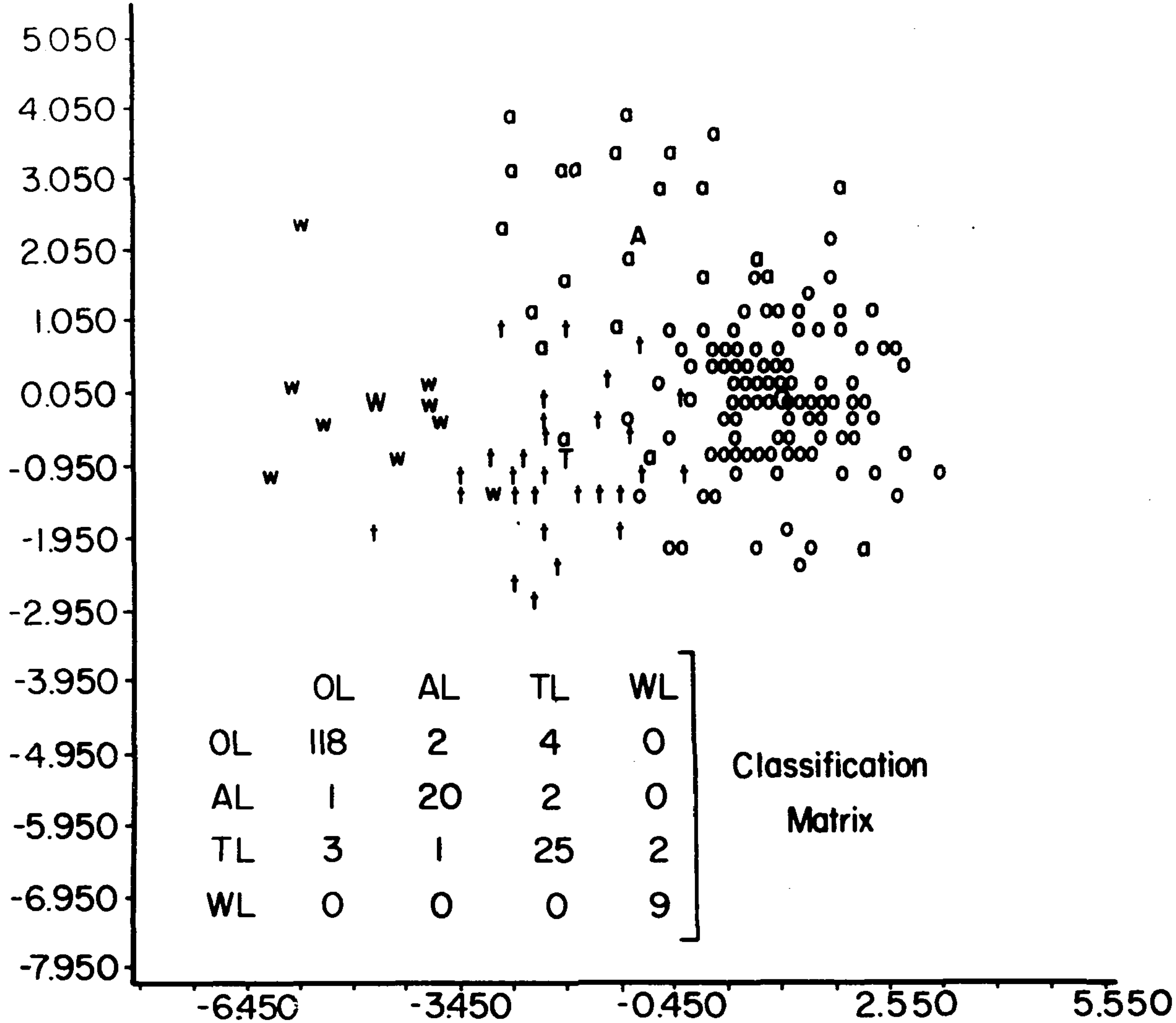
OL, o = *Lepus othus*

AL, a = *Lepus arcticus*

TL, t = *Lepus timidus*

WL, w = *Lepus townsendii*

The position of the lower case letters on the printout gives the location of each specimen. The position of the upper case letter gives the mean of each group so the relationship of the means for the four groups is seen.



Classification Matrix

	OL	AL	TL	WL
OL	118	2	4	0
AL	1	20	2	0
TL	3	1	25	2
WL	0	0	0	9

DISCUSSION AND CONCLUSIONS

The resulting growth curves for both weight and hind foot were similar to those obtained from known-age _Lepus californicus_ (Haskell and Reynolds 1947, Tiemeier 1965, Goodwin and Currie 1965), _Lepus townsendii_ (Bear and Hansen 1966), and _Lepus americanus_ (Severaid 1942) (Figs. 19 and 20).

The fast growth rate and short period of growth needed to attain minimum adult body weight is a very important factor in the survival of the hare through the long winter period. The winter prior to the study is an example of weather conditions more severe than average with maximum snow depth two to three times average and temperature 10 degrees below normal in March. A possible indication of the severity of weather conditions in winter was indicated by the fact that I found a juvenile tundra hare carcass intact on the mud flats near the mouth of the Kashunuk River in late June. The epiphyseal groove was still evident, therefore the hare probably died prior to January. Since the carcass was complete with the skin and dried flesh on the skeleton and was not disarticulated I believe it died from natural causes other than predation.

The high rate of growth in juveniles was possible because they were feeding on fast growing new vegetation; there was an abundant food source; and intermittent nursing occurred for a period of 2 months or more.

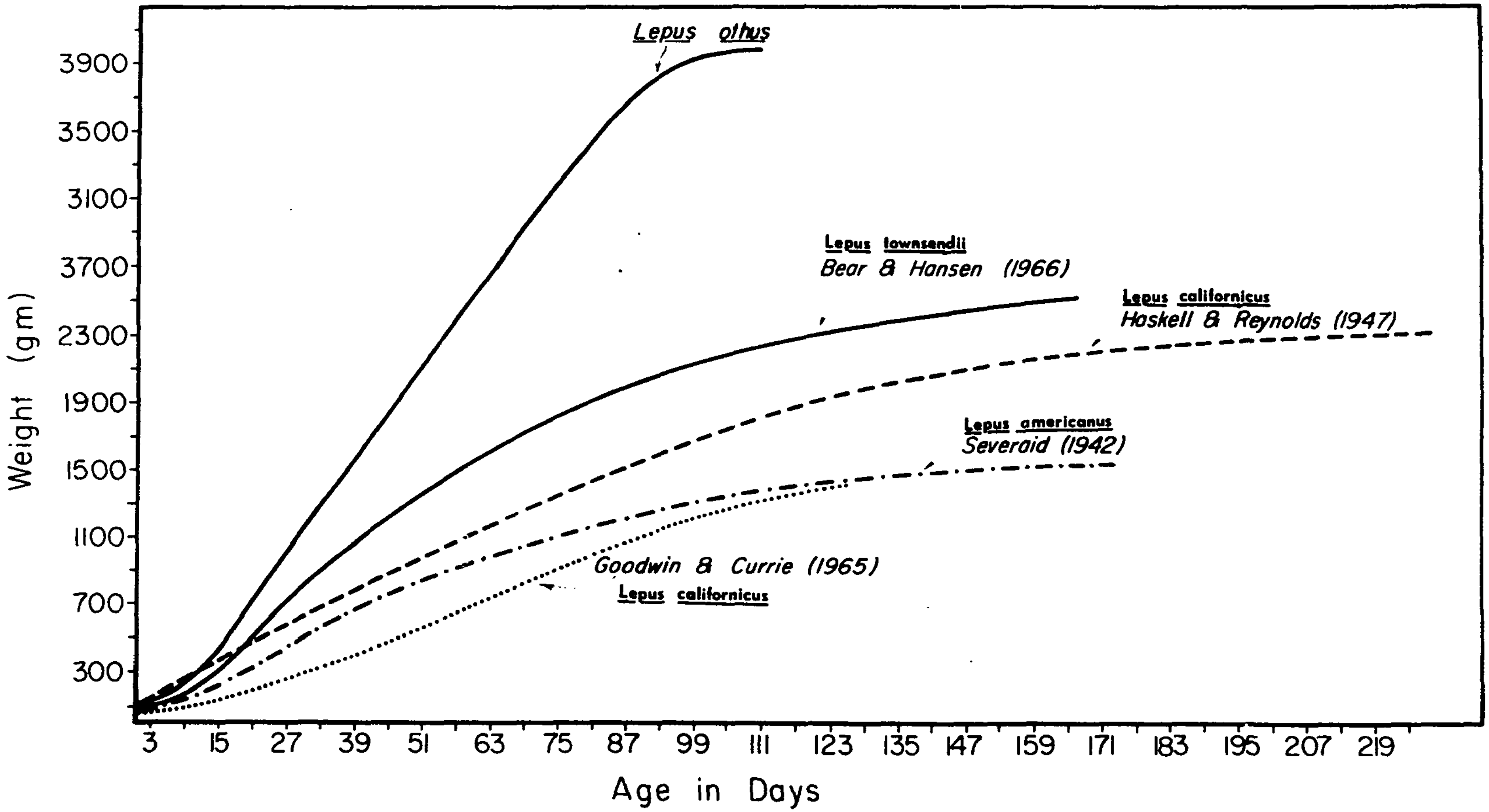


Figure 19. Comparison of known-age Lepus weight growth curves to Lepus othus growth curve.

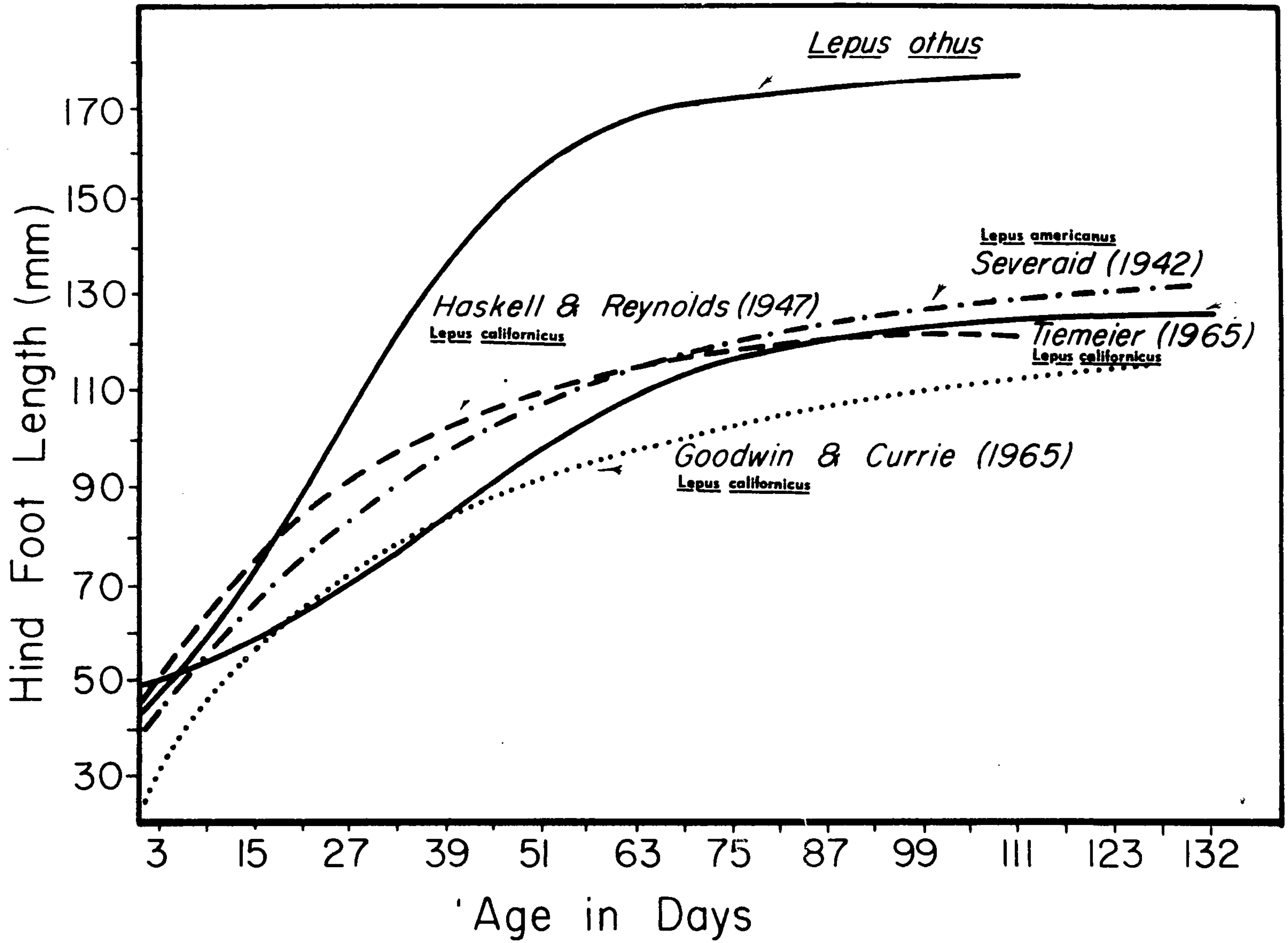


Figure 20. Comparison of known-age *Lepus* hind foot growth curves to *Lepus othus* growth curve.

An extended nursing period was indicated from the evidence that three females were lactating or showing signs of nursing a minimum of 5 weeks and a maximum of 9 weeks after parturition. Also, a juvenile hare approximately 2 months old had milk in its stomach. Manning (1943) collected an arctic hare on Baffin Island with enlarged mammae on 28 August 1938. Other published reports on nursing periods include: European hare in New Zealand 2 to 3 months (Flux 1967), mountain hare in Scotland 6 weeks (Flux 1970), and black-tailed jack rabbit in California 3 weeks (Lechleitner 1959) and 17 to 20 days in Kansas (Tiemeier 1965). The prolonged nursing period, hence increased parental care, enhances the survivorship of the young and helps maintain the high growth rate.

Bear and Hansen (1966) gave 14.5 gm/day as the average growth rate for known-age white-tailed jack rabbits in Colorado. It took 24 weeks for the young to attain 83% of average adult weight (2835 gm). Haskell and Reynolds (1947) gave an average growth rate of 9.8 gm/day for known-age black-tailed jack rabbits in Arizona and it took them 32 weeks to reach adult weight (2300 gm). Goodwin and Currie (1965) determined the average growth rate to be 10.6 gm/day in Utah and they attained 67% of adult weight (2092 gm) in 18 weeks. Severaid (1942) determined the growth rate of known-age snowshoe hares to be 10 gm/day in Maine and they attained adult weight (1530 gm) in 24 weeks. O'Farrell (1965) states that Alaska snowshoe hares attain adult weight (>1200 gm) in 90 to 120 days which would give an average growth rate of 10 to 13 gm/day. He states that a short growing season and early arrival of dense snows may have favored the natural selection of the rapid growth rate. This would allow the leverets to attain a weight level that would contribute to their survival through the long winter. Other published growth rates include: European hare in Poland 14 gm/day for 32 weeks (Pielowski 1971a), mountain hare in Scotland 10 gm/day for 33 weeks (Hewson 1968), and 22 gm/day in Norway (Walhovd 1965).

Growth of the hind foot in the tundra hare takes approximately the same amount of time to reach adult size as known-age white-tailed and black-tailed jack rabbits. However, the initial rapid growth rate, which is similar to that found in known-age black-tailed jack rabbits (Haskell and Reynolds 1947), continues for twice as long (Fig. 20). Goodwin and Currie (1965) found a similar but depressed growth curve for known-age black-tailed jack rabbits in Utah, and Severaid (1942) found a similar growth curve for known-age snowshoe hares. Tiemeier (1965) gave a hind foot growth curve for known-age black-tailed jack rabbits that was sigmoid in shape. The inflection point of the curve occurs at the same time as the tundra hare, but the final size is the same as that given by Haskell and Reynolds (1947).

Some skulls appear to be those of "old" animals (Fig. 21) by the pronounced development of the anterior supraorbital process. But until known-age hares are available skulls can only be classified as juvenile and adult. Juveniles are individuals less than 9 months old; adults are older than 9 months.

Pielowski (1971b) has determined from a long-term study of non-hunted European hares that the maximum age attained was 12.5 years. He found 19 hares 5.5 years old or older in a population of approximately 5800 hares. In a separate paper (Pielowski 1971a) he shows that from tagged and recaptured hares (N=114) of this non-hunted population that

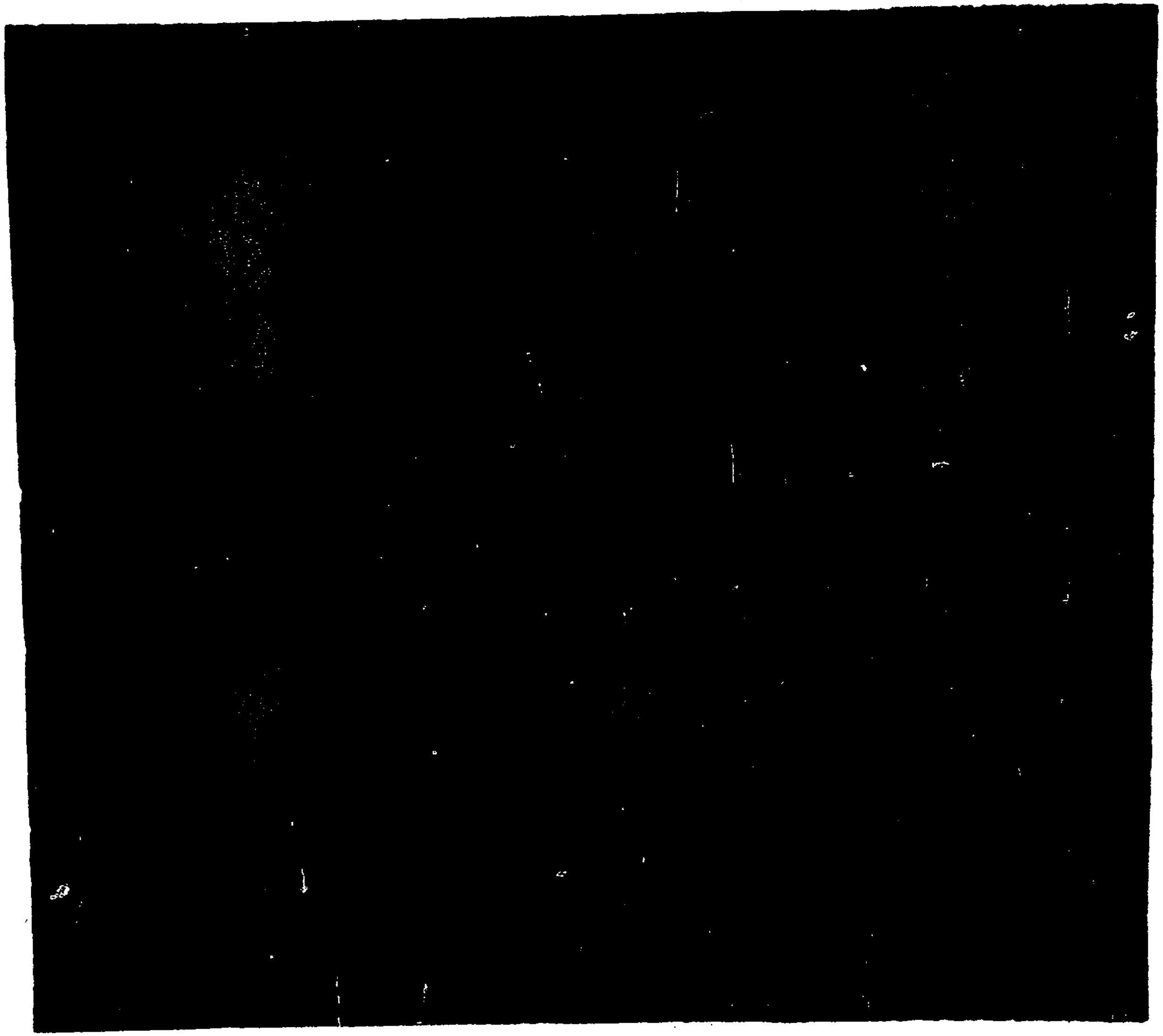


Figure 21. Skulls of "old" tundra hares.

the body weight increases up to the fourth year of life. The weight change was from 3870 gm average weight for one year olds to 4390 gm average for four year olds, a change of 13.4%.

At this time there is not sufficient information available to estimate average life span or maximum longevity for the tundra hare. However, two things indicate that "old" animals do exist: (1) the pronounced development of the anterior supraorbital process and (2) the weight change from 4800 gm average weight to a maximum weight of 6490 gm, an increase of 35%.

Tundra hare prenatal mortality consisted of pre- and postimplantation mortality. The prenatal mortality that I observed may be high or low due to one or any combination of the following factors: (1) small sample size (N=3), (2) severe conditions such as food shortage or extreme weather conditions, or (3) part of the sample being females that were breeding for the first time. The female with the highest preimplantation loss (66.7%) was believed to be a yearling. The weather during the winter prior to my study was more extreme than average and this extreme weather could cause food shortage through increased snow depth. The combination of food shortage and severe weather conditions would impose a physiological stress on the hares and this stress could cause an increased prenatal mortality. Flux (1967, 1970) and Tiemeier (1965) state that prenatal mortality may be caused by severe conditions such as food shortage or extreme weather conditions. James and Seabloom (1969b) determined that prenatal mortality was higher during a female's first breeding season.

James and Seabloom (1969b) found a prenatal loss of 21% in white-tailed jack rabbits in North Dakota, consisting of 16.7% preimplantation and 4.6% postimplantation loss. In California, black-tailed jack rabbits showed a prenatal loss of 47.4% (Lechleitner 1959) including 6% preimplantation and 41.4% postimplantation loss. European hares in New Zealand had a prenatal loss of 39.2% (Flux 1967) and this consisted of 15.8% preimplantation and 23.4% postimplantation loss. Flux (1970) gave 46.9% prenatal loss in Scotland mountain hares composed of 12.1% preimplantation and 34.8% postimplantation loss. A prenatal loss of 43.3% consisting of 34.6% preimplantation and 7.7% postimplantation loss was found in the tundra hare. These prenatal losses fall within the range of values given by the above authors, therefore I consider them to be good estimates of tundra hare prenatal mortality.

The large litter size of the tundra hare (six to seven) is related to the fact that only one litter per year is produced. Spencer and Steinhoff (1968) show that as the maximum number of opportunities for reproduction decreases an advantage is given to phenotypes producing large litters. The large litter size takes more reproductive effort by the female, but when the longer period of parental care is considered the potential rate of increase is maximized. The litter size of the tundra hare when compared to other large hares of North America shows a positive correlation between latitude and litter size (Table 8). Dufresne (1946) states that the tundra hare has five to seven young.

The arctic hare in Greenland was reported to have one litter per year of five or six young by Degerbol and Freuchen (1935). Manniche (1910) states that they have one litter per year with an average of six young and a range of two to seven. Pedersen (1966) gives the average

Table 8. Comparison of litter size to latitude for large hares of North America.

Species	Average Litter Size	Latitude
Lepus othus[1]	6.3	60
Lepus townsendii[2]	4.8	45
Lepus californicus[3]	2.27	35
Lepus alleni[4]	1.94	32

Correlation Coefficient (r) = 0.9774   Significance $P<0.01$

[1]This study.

[2]Combined average litter size from Bear and Hansen (1966) and James and Seabloom (1969b).

[3]Combined average litter size from Haskell and Reynolds (1947), Tiemeier (1965) and Lechleitner (1959).

[4]Average litter size from Hall and Kelson (1959).

litter size to be seven. Soper (1928) states that the arctic hares of Baffin Island have one litter per year with four to six young.

Other published litter data for hares include: black-tailed jack rabbit in Arizona four to six litters/year and 2.8 young/litter (Haskell and Reynolds 1947), Kansas 4.6 litters/year and 2.8 young/litter (Tiemeier 1965), and California 4.27 litters/year and 2.3 young/litter (Lechleitner 1959); white-tailed jack rabbit in Colorado 1 litter/year and 5 young/litter (Bear and Hansen 1966) and in North Dakota 3.29 litters/year and 4.6 young/litter (James and Seabloom 1969b); mountain hare in Scotland 2.75 litters/year with 2.3 young/litter (Flux 1970); European hare in New Zealand 4.59 litters/year with 2.14 young/litter (Flux 1967); snow-shoe hare in Maine 3 litters/year with 2.88 young/litter (Severaid 1942).

The parturition period seems to coincide with the loss of snow cover in the spring. Snow cover is usually gone by the end of May (Fig. 4). Dau (1972) showed that only 10% of the snow cover was left by 28 May 1972 and it consisted of drifts and patches of snow on sheltered north slopes. Since the young are precocial their survival is enhanced if they are born after the snow has melted, when food is abundant and ambient temperatures are high. Also, the young are brown when they are born, which would render them susceptible to predation on snow.

Arctic hares in Greenland breed at the end of April (Pedersen 1966) and have their young the last of May or June (Degerbol and Freuchen 1935, Pedersen 1966). The arctic hares on Baffin Island give birth in late June or early July (Soper 1928). But on Banks Island parturition occurs in a short period in mid-June (Manning and Macpherson 1958).

The food habits analysis shows that the tundra hare utilizes willow (Salix alaxensis) and crowberry (Empetrum nigrum) for the majority of its food in April and May. Soper (1928) found the arctic hare on Baffin Island utilized dwarf willows (Salix arctica and S. herbacea) and crowberry (Empetrum nigrum) as the chief items of diet in winter. Salix, Empetrum and Saxifraga are stated to be the main foods of arctic hares in Greenland by Degerbol and Freuchen (1935), but only Salix and Saxifraga are given as the preferred food by Manniche (1910). Dufresne (1946) states that tundra hares eat alpine shrubs, twigs, and grasses.

I observed that as the snow melted in the spring on my study area an abundance of crowberry with fruit had come through the winter in apparently good condition. In early spring hares were seen feeding at the edge of melting snow patches, where crowberries were abundant, and the stomachs of two adults collected during the same time period contained large quantities of Empetrum berries and leaves.

I did not observe any hares during the parturition period, but an adult and a young hare, approximately 300 mm long, were sighted 19 June 1973, on the tidal flats near the mouth of the Aknerkochik River about 32 km southeast of my study area. Walkinshaw (1947) found a litter of newborn tundra hares in upland tundra 38 km west of Bethel on the Johnson River. Field reconnaissance in my study area in late November showed, on the basis of the distribution of tracks, that hares were utilizing all parts of the study area from the sedge meadows to the upper slopes of the Askinuk Mountains.

The red fox, golden eagle, snowy owl, and arctic fox are considered to be the potential predators as evidenced by the tundra hare remains found in raptor castings, predator scats, and at kill sites. Dufresne (1946) gives the following as tundra hare predators: snowy owl, red fox, arctic fox, wolverine, wolf, gyrfalcon, and weasel. The red fox is present on the study area throughout the year and is probably capable of taking adult as well as juvenile hares. Therefore it is considered the most important predator. The juvenile hare that was killed in July was believed to have been taken by a red fox. The arctic fox is present year round but may not be able to kill an adult hare in good condition. Its predation is believed to be primarily on young hares. The predator scat that contained hare remains could only be identified as that of a fox. The golden eagle is present only during the spring to fall period and it is capable of taking both adult and juvenile hares. One casting collected at a golden eagle nest contained tundra hare remains. The snowy owl is present from late fall to early spring and it is considered capable of taking both adult and juvenile hares. The adult hare remains found near a bird mound on the bluff above Panowat Spit were believed to have been the result of predation by a snowy owl. Juveniles are the most subject to predation and may also be preyed upon by rough-legged hawks during the summer while small.

The range of the tundra hare given here probably includes the majority of all tundra hares. It is similar to that shown by Rausch (1963) and I believe it to be more realistic than the range given by other authors (Bee and Hall 1956, Hall and Kelson 1959, Howell 1936). Bee and Hall (1956) list only one specimen (unverified) collected outside the range given here. The specimen, a skeleton obtained in April 1898 on the Ikpikpuk River, was later lost or misplaced. A 480 km range extension seems difficult to justify on the basis of one unverified specimen. Pruitt (1966) believes that the tundra hare was found in the Cape Thompson area approximately 150 to 200 years ago (1766 to 1816) based on bones of at least two individuals found in a house pit by West (1966) and based on local Eskimo lore and traditions. Since the bones were found in association with human habitation they were probably food items and could have been brought to Cape Thompson from a more distant area by the Eskimos residing there or through trade. This evidence seems an inadequate basis for extending the range of the tundra hare.

A latitudinal size cline was found to exist within the tundra hare species. The three populations that were compared are located in the following parts of the range: LOI -- southern, Alaska Peninsula area; LOII -- central, Yukon-Kuskokwim Delta area; and LOIII -- northern Seward Peninsula-Kotzebue area. The means of the following measurements all exhibited a similar size cline: hind foot length, greatest length (I), basilar length, zygomatic breadth (I), cranial breadth, diastema length, maxillary tooth row, zygoma length, inion-incisor length, greatest length (II), condylobasal length, length of incisive foramen, breadth across auditory bullae, zygomatic breadth (II), greatest length of mandible, and incisor-basisphenoid length. A positive correlation between size and latitude (Bergmann's Rule) was exhibited over the entire range of the species. The variation within the species can be attributed to the geographical size cline, therefore I do not feel that there is a basis for recognition of subspecies in the tundra hare.

Sexual dimorphism was not found in the body or skull measurements of the tundra hare. Therefore all analyses used skull measurements without separating the sexes. Manning and Macpherson (1958) stated that skulls of the Canadian arctic hares did not show sexual dimorphism. Walhovd (1965) found that the body measurements of the mountain hare in Norway were not significantly different between the sexes. Other published reports that show sexual dimorphism include: black-tailed jack rabbits in Kansas -- the females were 12.3% larger (Tiemeier 1965); and in California the females were 11.3% larger (Lechleitner 1959); white-tailed jack rabbits in Colorado -- the females were 17.1% larger (Bear and Hansen 1966) and in North Dakota the females were 16.4% larger (James and Seabloom 1969a); and mountain hare in Scotland -- the females were 12% larger (Flux 1970).

The mean skull and body measurements of *Lepus othus* were larger than *Lepus arcticus* or *Lepus timidus*, which would not be true if the three species or either pair were part of a size cline. Since *Lepus timidus* is found at the same latitudes as *Lepus othus* and most of the range of *Lepus arcticus* is located at higher latitudes a size cline variation between the species should have *Lepus othus* the same size as *Lepus timidus* and smaller than *Lepus arcticus*, which was not found to be true.

The Generalized Distance, which shows the dissimilarity between two groups, shows that *Lepus timidus* is closer to *Lepus arcticus* than *Lepus othus*, which is just opposite of the actual geographic distances.

By utilizing the maximum overall Generalized Distance of *Lepus othus* (D=10.15) and the minimum Generalized Distance between *Lepus townsendii* and the closest of the three arctic hare species (D=10.3) a measure of species distance (minimum D value) can be obtained. This minimum D is used to determine if two groups being compared are possible species. From these data a specific distance is considered to be a Generalized Distance >10.3. The Generalized Distances between the three arctic hare species vary from 12 to 17.8, all greater than the defined specific distance.

I consider the three arctic hare species compared to be valid species using the following criteria:

1. They can be separated on the basis of skull morphology.
2. They are geographically isolated from each other.
3. Due to geographic isolation, there is no gene flow between the species.

Dr. R. L. Rausch (personal communication) also believes that *Lepus othus* is a valid (distinct) species and not conspecific with *Lepus timidus* of Siberia or *Lepus arcticus* of Canada. This is based on the fact that four Beringian relict species (*Ochotona collaris*, *Marmota broweri*, *Ovis dalli*, *Microtus miurus*) of northwestern North America have been shown to be distinct species on the basis of their chromosomes. It is then logical that other Beringian relict species, such as *Lepus othus*, are also distinct species.

I was not able to eliminate the following confounding factors from the systematic analysis: (1) age variation within each species; (2) similar morphological development of the three arctic hare species caused by their evolving in similar habitats under similar adaptive pressures; (3) apparent conservative evolution shown in the genus *Lepus*; and (4) not having an adequate sample of all species to include the entire range of variation. These factors may keep the specific differences from being easily seen.

APPENDIX 1. Tundra hare specimens examined. Specimen location and collection data and body measurements data.

KEY:

USNM = United States Museum of Natural History

CRNWR = Clarence Rhode National Wildlife Refuge

David Eisenhauer = private collection

ADFG = Alaska Department of Fish and Game

UA = University of Alaska Museum

PANS = Philadelphia Academy of Natural Science

PSMNH = Puget Sound Museum of Natural History

APPENDIX 1. Tundra hare specimens examined.

Data	Specimen		Collection					Total		Hind	Ear from	Body
No.	Number	Location	Date	Location	Sex	Age	Weight	Length	Tail	Foot	Notch	Length
1	HLA-1	USNM	5-6-1973	14.5 km SW of Old Chevak	M	A	4082	670	-	185	92	-
2	HLA-2	USNM	5-7-1973	24 km SW of Old Chevak	F	A	4309	663	70	174	82	593
3	HLA-3	USNM	5-7-1973	16 km SW of Old Chevak	F	A	4990	665	61	179	90	604
4	HLA-4	USNM	5-8-1973	Ninglikfak R. near Chevak	F	A	3969	683	74	180	84	609
5	HLA-5	USNM	5-8-1973	Ninglikfak R. near Chevak	F	A	4593	686	64	180	88	622
6	HLA-6	USNM	6-22-1973	30 km SW of Old Chevak	-	J	-	646	58	174	82	588
7	HLA-7	USNM	8-1-1973	S18-T18N-R91W near Kokechik Bay	M	J	2211	560	65	152	85	495
8	HLA-8	USNM	8-1-1973	S18-T18N-R91W near Kokechik Bay	M	J	2070	592	68	150	81	524
9	HLA-9	USNM	8-7-1973	S18-T18N-R91W near Kokechik Bay	F	A	5398	-	72	181	102	-
10	HLA-10	USNM	7-22-1973		F	A	-	684	114	178	114	570
11	PGM-23	CRNWR	5-23-1971	S32-T15N-R89W near Old Chevak	F	A	4621	673	63	182	-	610
12	DIE-1	David Eisenhauer	5-25-1972	S19-T18N-R91W near Kokechik Bay	F	A	5450	-	-	-	-	-
13	JJB 2374	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4250	-	-	195	99	615
14	JJB 2376	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4250	-	-	185	91	593
15	JJB 2375	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4600	-	-	188	91	612

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location	Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
16	JJB 2377	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4700	-	-	197	101	624
17	JJB 2378	ADFG	5-7-1971	Arctic R., Seward Peninsula	M	A	4150	-	-	188	93	591
18	JJB 2381	ADFG	5-1-1971	Serpentine Spr., Seward Peninsula	M	A	4200	-	-	192	91	595
19	JJB 2382	ADFG	5-7-1971	Arctic R., Seward Peninsula	M	A	3900	-	-	186	82	580
20	JJB 2383	ADFG	5-7-1971	Arctic R., Seward Peninsula	M	A	4300	-	-	181	89	620
21	JJB 2384	ADFG	5-7-1971	Arctic R., Seward Peninsula	F	A	4850	-	-	184	92	618
22	JJB 2385	ADFG	5-7-1971	Arctic R., Seward Peninsula	M	A	4300	-	-	184	92	604
23	JJB 2386	ADFG	5-7-1971	Arctic R., Seward Peninsula	F	A	4700	-	-	190	89	612
24	JJB 2387	ADFG	5-4-1971	Arctic R., Seward Peninsula	F	A	4350	-	-	189	91	602
25	JJB 2389	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4250	-	-	196	88	619
26	JJB 2390	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4800	-	-	194	86	643
27	JJB 2392	ADFG	5-7-1971	Arctic R., Seward Peninsula	F	A	5200	-	-	195	93	615
28	JJB 2393	ADFG	5-7-1971	Arctic R., Seward Peninsula	F	A	4150	-	-	187	82	576
29	JJB 2394	ADFG	5-7-1971	Arctic R., Seward Peninsula	F	A	4600	-	-	187	88	599
30	JJB 2396	ADFG	5-4-1971	Arctic R., Seward Peninsula	F	A	4800	-	-	190	93	632

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location	Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
31	JJB 2397	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4500	-	-	195	94	620
32	JJB 2400	ADFG	5-7-1971	Arctic R., Seward Peninsula	M	A	4450	-	-	192	92	621
33	JJB 2403	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4600	-	-	185	91	618
34	JJB 2404	ADFG	5-4-1971	Arctic R., Seward Peninsula	F	A	4800	-	-	191	91	600
35	JJB 2405	ADFG	5-4-1961	Arctic R., Seward Peninsula	M	A	4100	-	-	180	87	632
36	JJB 2406	ADFG	4-2-1971	Serpentine R., Seward Peninsula	M	A	5443	663	44	187	94	619
37	JJB 2407	ADFG	3/4-1971	Serpentine R., West Fork	-	A	-	-	-	-	-	-
38	JJB 2408	ADFG	3/4-1971	Ear Mtn., Seward Peninsula	-	A	-	-	-	-	-	-
39	JJB 2409	ADFG	3/4-1971	Ear Mtn., Seward Peninsula	-	A	-	-	-	-	-	-
40	JJB 2410	ADFG	3/4-1971	Whitefish Lake, Seward Peninsula	-	A	-	-	-	-	-	-
41	JJB 2411	ADFG	3/4-1971	Serpentine R., West Fork	-	A	-	-	-	-	-	-
42	JJB 2412	ADFG	3/4-1971	Ear Mtn., Seward Peninsula	-	A	-	-	-	-	-	-
43	JJB 2413	ADFG	3/4-1971	Whitefish Lake, Seward Peninsula	-	A	-	-	-	-	-	-
44	JJB 2414	ADFG	3/4-1971	Teller	-	A	-	-	-	-	-	-
45	JJB 2415	ADFG	3/4-1971	Teller	-	A	-	-	-	-	-	-

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location
46	JJB 2416	ADFG	3/4-1971	Teller
47	JJB 2417	ADFG	3-3-1972	Arctic R., Seward Peninsula
48	JJB 2418	ADFG	3-1972	Arctic R., Seward Peninsula
49	JJB 2419	ADFG	3-1972	Arctic R., Seward Peninsula
50	JJB 2420	ADFG	3-1972	Arctic R., Seward Peninsula
51	JJB 2421	ADFG	3-1972	Arctic R., Seward Peninsula
52	JJB 2422	ADFG	3-1972	Arctic R., Seward Peninsula
53	JJB 2423	ADFG	3-1972	Arctic R., Seward Peninsula
54	JJB 2425	ADFG	3-1972	Arctic R., Seward Peninsula
55	JJB 2426	ADFG	3-1972	Arctic R., Seward Peninsula
56	JJB 2427	ADFG	3-1972	Arctic R., Seward Peninsula
57	JJB 2428	ADFG	3-1972	Arctic R., Seward Peninsula
58	JJB 2430	ADFG	3-1972	Arctic R., Seward Peninsula
59	JJB 2431	ADFG	3-1972	Arctic R., Seward Peninsula
60	JJB 2432	ADFG	3-1972	Arctic R., Seward Peninsula

Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
-	A	-	-	-	-	-	-
F	A	4281	625	-	169	88	-
M	A	5528	675	-	183	93	-
M	A	4394	683	-	185	93	-
F	A	4678	669	-	191	94	-
F	A	4564	641	-	178	90	-
M	A	5018	660	59	185	93	601
F	A	5188	675	68	183	89	607
M	A	4252	640	56	176	94	584
F	A	5103	660	75	191	92	585
M	A	4691	669	66	192	92	603
M	A	4281	648	67	181	87	581
M	A	5216	687	70	186	91	617
F	A	5471	664	77	182	87	587
F	A	4252	634	50	178	87	584

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location
61	JJB 2433	ADFG	3-1972	Arctic R., Seward Peninsula
62	JJB 2434	ADFG	3-1972	Arctic R., Seward Peninsula
63	JJB 2435	ADFG	3-1972	Arctic R., Seward Peninsula
64	JJB 2436	ADFG	3-1972	Arctic R., Seward Peninsula
65	JJB 2437	ADFG	3-1972	Arctic R., Seward Peninsula
66	JJB 2438	ADFG	3-1972	Arctic R., Seward Peninsula
67	JJB 2439	ADFG	3-1972	Arctic R., Seward Peninsula
68	JJB 2440	ADFG	3-1972	Arctic R., Seward Peninsula
69	JJB 2441	ADFG	1-22-1972	Arctic R., Seward Peninsula
70	JJB 2442	ADFG	3-1972	Arctic R., Seward Peninsula
71	JJB 2443	ADFG	3-1972	Arctic R., Seward Peninsula
72	JJB 2444	ADFG	3-1972	Arctic R., Seward Peninsula
73	JJB 2445	ADFG	1-22-1972	Arctic R., Seward Peninsula
74	JJB 2446	ADFG	3-1972	Arctic R., Seward Peninsula
75	JJB 2447	ADFG	3-1972	Arctic R., Seward Peninsula

Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
F	A	4990	689	78	190	88	611
M	A	5443	668	75	185	90	593
M	A	4394	633	66	185	96	567
F	A	5018	659	75	194	92	584
M	A	4564	661	65	186	86	596
M	A	5471	670	73	194	88	597
M	A	4479	643	69	186	90	574
M	A	4819	651	61	188	95	590
F	A	5330	662	79	192	96	583
M	A	5698	682	60	197	88	622
M	A	5840	661	61	190	85	600
M	A	6492	670	59	195	96	611
M	A	4961	-	77	190	96	-
F	A	4621	665	97	180	96	562
M	A	5273	655	77	187	88	578

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location	Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
76	JJB 2448	ADFG	3-1972	Arctic R., Seward Peninsula	M	A	5216	676	70	185	86	606
77	JJB 2450	ADFG	3-1972	Arctic R., Seward Peninsula	F	A	4734	660	91	175	93	551
78	JJB 2451	ADFG	3-1-1972	Arctic R., Seward Peninsula	F	A	-	657	82	184	93	575
79	JJB 2453	ADFG	3-1972	Arctic R., Seward Peninsula	M	A	5216	652	-	186	88	-
80	UA 342	UA	8-21-1952	Old Chevak	F	J	2875	584	90	170	-	474
81	UA 1535	UA	Winter 52-53	Wales	-	A	-	-	-	-	-	-
82	CPD-16	UA	7-22-1972	14.5 km SW of Old Chevak	F	A	6294	635	-	180	90	-
83	CPD-18	UA	7-19-1972	14.5 km SW of Old Chevak	F	J	1800	-	-	153	88	-
84	CPD-19	UA	8-29-1972	Tutakoke R. mouth	F	J	3710	480	54	173	96	426
85	CPD-20	UA	8-29-1972	Tutakoke R. mouth	F	J	3200	455	52	172	90	403
86	PGM	UA	9-3-1972	4 km SE of Old Kashunuk	M	J	3250	537	48	172	92	489
87	3780	PANS	7-31-1895	Choris Peninsula, Kotzebue Sound	F	A	-	580	-	181	94	-
88	36216	USNM	-	Alaska	-	A	-	-	-	-	-	-
89	36214	USNM	-	Alaska	-	A	-	-	-	-	-	-
90	36213	USNM	-	Alaska	-	A	-	-	-	-	-	-

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location
91	36212	USNM	-	Alaska
92	15880	USNM	-	St. Michaels
93	15879	USNM	-	St. Michaels
94	15878	USNM	-	St. Michaels
95	14510	USNM	-	"Yukon"
96	8645	USNM	-	"Yukon"
97	7218	USNM	-	Nulato R.
98	6120	USNM	-	"Youkon"
99	114139	USNM	3-1880	St. Michaels
100	15884	USNM	-	St. Michaels
101	15882	USNM	3-1887	St. Michaels
102	15881	USNM	-	St. Michaels
103	260900	USNM	8-4-1936	Little Diomede Island
104	245470	USNM	9-15-1924	Nome
105	251455	USNM	11-15-1934	Teller
106	251456	USNM	11-15-1934	Teller

Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
F	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
F	J	-	565	65	170	-	500
-	A	4309	-	-	-	-	-
-	A	-	-	-	-	-	-

APPENDIX 1, continued.

Data	Specimen		Collection	
No.	Number	Location	Date	Location
107	210816	USNM	2-24-1913	Bethel
108	203807	USNM	1-16-1913	Bethel
109	206457	USNM	11-1-1914	Bethel
110	207870	USNM	2-22-1917	Kwiklauk
111	227877	USNM	12-20-1916	Akiak
112	227869	USNM	2-19-1917	Bethel
113	227878	USNM	1-13-1917	Bethel
114	251454	USNM	11-15-1934	Teller
115	251457	USNM	11-15-1934	Teller
116	227871	USNM	1-18-1917	Bethel
117	227872	USNM	1-18-1917	Bethel
118	227879	USNM	1-18-1917	Bethel
119	210815	USNM	2-24-1913	Bethel
120	227876	USNM	2-14-1917	Bethel
121	226456	USNM	11-1-1914	Bethel
122	227868	USNM	3-1-1917	Bethel

Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
F	A	-	650	85	176	-	565
-	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
F	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
F	A	-	-	-	-	-	-
-	A	4536	-	-	-	-	-
-	A	-	-	-	-	-	-
F	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
M	A	-	690	104	189	-	586
M	A	-	-	-	-	-	-
-	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location	Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
123	227882	USNM	2-13-1917	Bethel	F	A	-	-	-	-	-	-
124	227880	USNM	1-20-1917	Bethel	F	A	-	-	-	-	-	-
125	227866	USNM	1-18-1917	Bethel	M	A	-	-	-	-	-	-
126	227865	USNM	1-18-1917	Bethel	M	A	-	-	-	-	-	-
127	167775	USNM	2-5-1909	Nome	-	A	-	-	-	-	-	-
128	227875	USNM	1-20-1917	Bethel	M	A	-	-	-	-	-	-
129	227874	USNM	1-9-1917	Bethel	F	A	-	-	-	-	-	-
130	227867	USNM	1-22-1917	Bethel	F	A	-	-	-	-	-	-
131	227873	USNM	2-24-1917	Kwiklauk	M	A	-	-	-	-	-	-
132	181249	USNM	1-7-1913	120 km below Bethel	-	A	-	-	-	-	-	-
133	38263	USNM	12-30-1881	Nushagak	-	A	-	-	-	-	-	-
134	120035	USNM	1902	Cold Bay	-	A	-	-	-	-	-	-
135	96534	USNM	9-11-1896	Kawatna Bay, Shelikoff Strait	F	J	-	-	-	-	-	-
136	246456	USNM	5-25-1925	Pavlof Mtn.	M	A	-	570	65	170	-	505
137	127745	USNM	1903	Between Portage Bay & Becharof L.	-	A	-	-	-	-	-	-

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location	Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
138	128074	USNM	1903	Between Portage Bay & Becharof L.	-	A	-	-	-	-	-	-
139	128075	USNM	1903	Between Portage Bay & Becharof L.	-	A	-	-	-	-	-	-
140	206785	USNM	10-23-1914	Chignik	F	A	-	597	38	172	-	559
141	127743	USNM	1903	Between Portage Bay & Becharof L.	-	A	-	-	-	-	-	-
142	127744	USNM	1903	Between Portage Bay & Becharof L.	-	A	-	-	-	-	-	-
143	128076	USNM	1903	Between Portage Bay & Becharof L.	-	A	-	-	-	-	-	-
144	176656	USNM	1911	Chignik	-	A	-	-	-	-	-	-
145	203278	USNM	6-9-1913	Sandpoint, Pokof Island	M	A	-	610	76	152	-	534
146	15883	USNM	2-1877	St. Michaels	-	A	-	-	-	-	-	-
147	98068	USNM	7-8-1899	Stepovak Bay	-	A	-	-	-	-	-	-
148	95733	UM	6-10-1946	Johnson R. 30 mi W of Bethel	F	A	3250	610	80	161	84	530
149	75055	UM	5-1-1954	Izembek Bay, Bering Sea	M	A	-	-	-	-	-	-
150	75054	UM	5-1-1954	Izembek Bay, Bering Sea	F	A	-	-	-	-	-	-
151	91026	UM	6-12-1946	Johnson R. 48 km W of Bethel	M	J	105	176	20	45	24	156
152	PGM-30	CRNWR	5-20-1971	14.5 km SW of Old Chevak	F	A	4139	-	63	178	102	-

APPENDIX 1, continued.

Data No.	Specimen Number	Specimen Location	Collection Date	Collection Location	Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
153	8781	USNM	-	NW of Nulato R.	F	-	-	-	-	-	-	-
154	13886	USNM	2-1878	St. Michaels	-	-	-	-	-	-	-	-
155	13887	USNM	1-3-1880	St. Michaels	-	-	-	-	-	-	-	-
156	27159	USNM	-	Alaska	-	-	-	-	-	-	-	-
157	37160	USNM	-	Alaska	-	-	-	-	-	-	-	-
158	5959	UA	9-22-1960	Nome-Rock Creek	F	J	3969	635	76	178	-	559
159	5960	UA	9-22-1960	Nome-Rock Creek	M	J	3939	660	76	178	86	584
160	5961	UA	10-10-1960	Salmon Lake Road, Nome	M	A	4536	651	76	184	89	575
161	4132	UA	3-30-1957	Kotzebue	F	A	5000	665	60	164	90	605
162	JJB 640	ADFG	3-6-1966	Eldorado Creek, Seward Peninsula	M	A	-	-	-	-	-	-
163	JJB 832	ADFG	12-13-1966	Anvil Mtn., Seward Peninsula	M	A	-	-	-	-	-	-
164	JJB 1047	ADFG	12-28-1967	Mary's Igloo	F	A	-	-	-	-	-	-
165	JJB 839	ADFG	12-22-1966	Anvil Mtn., Seward Peninsula	-	A	-	-	-	-	-	-
166	JJB 2307	ADFG	10-13-1967	3 km E of Nome	-	A	-	-	-	-	-	-
167	JJB 643	ADFG	2-5-1966	Solomen, Seward Peninsula	M	A	4196	618	-	171	81	-

APPENDIX 1, continued.

Data	Specimen		Collection	
No.	Number	Location	Date	Location
168	JJB 815	ADFG	3-23-1966	White Mtn., Seward Peninsula
169	JJB 832	ADFG	12-13-1966	5.6 km NE of Nome
170	JJB 851	ADFG	2-22-1967	Anvil Mtn., Seward Peninsula
171	SHH(A)	ADFG	1-1971	Arctic R., Seward Peninsula
172	SHH(B)	ADFG	1-1971	Arctic R., Seward Peninsula
173	SHH(C)	ADFG	1-1971	Arctic R., Seward Peninsula
174	JJB 2108	ADFG	10-1967	Nome-Teller Road
175	R-1	PSMNH	5-16-1954	Becharof L.
176	R-2	PSMNH	6-1-1957	Hooper Bay
177	R-3	PSMNH	5-13-1954	Wide Bay
178	JJB 2379	ADFG	5-4-1971	Arctic R., Seward Peninsula
179	JJB 2380	ADFG	5-1-1971	Serpentine Spr., Seward Peninsula
180	JJB 2388	ADFG	5-4-1971	Arctic R., Seward Peninsula
181	JJB 2391	ADFG	4-3-1971	Kuzitrin R., Seward Peninsula
182	JJB 2395	ADFG	5-4-1971	Arctic R., Seward Peninsula

Sex	Age	Weight	Total Length	Tail	Hind Foot	Ear from Notch	Body Length
F	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
M	A	5557	-	-	-	-	-
F	A	-	-	-	-	-	-
M	A	-	-	-	-	-	-
F	A	-	-	-	-	-	-
-	J	-	-	-	-	-	-
F	A	5500	-	25	170	-	-
F	A	5500	660	74	180	-	586
-	-	-	-	-	-	-	-
F	A	4150	-	-	188	93	575
F	A	4950	-	-	194	92	627
M	A	4500	-	-	190	95	615
F	A	5150	-	-	189	93	620
M	A	4400	-	-	191	85	619

APPENDIX 1, continued.

Data	Specimen		Collection					Total		Hind	Ear from	Body
No.	Number	Location	Date	Location	Sex	Age	Weight	Length	Tail	Foot	Notch	Length
183	JJB 2398	ADFG	4-22-1971	Serpentine R., Seward Peninsula	F	A	5100	-	-	193	91	623
184	JJB 2399	ADFG	5-7-1971	Arctic R., Seward Peninsula	F	A	4500	-	-	175	94	635
185	JJB 2401	ADFG	5-4-1971	Arctic R., Seward Peninsula	F	A	4900	-	-	189	92	620
186	JJB 2402	ADFG	5-4-1971	Arctic R., Seward Peninsula	M	A	4550	-	-	191	101	625
187	JJB 2424	ADFG	3-1972	Arctic R., Seward Peninsula	M	A	4309	642	72	179	89	570
188	JJB 2429	ADFG	3-1972	Arctic R., Seward Peninsula	M	A	5642	673	56	185	92	617
189	JJB 2449	ADFG	3-1972	Arctic R., Seward Peninsula	F	A	5075	669	84	191	91	585

APPENDIX 2. Explanation of the skull measurements and the data from the tundra hare skulls.

The following 24 skull measurements were taken on all hare skulls examined. Figure 22 shows how each measurement was made on the skull and the numbers on the figure correspond to the following descriptions of the measurements.

1. Greatest Length (I) - Anteriormost face of upper incisors to posterior border of interparietal.
2. Basilar Length - Posterior edge of alveolus of I^2 to inferior border of the foramen magnum.
3. Length of Nasals - Greatest diagonal length of the longest nasal.
4. Width of Nasals - Greatest breadth of nasals near posterior border.
5. Zygomatic Breadth (I) - Greatest breadth across the squamosal portion of the zygomatic arch.
6. Depth of Rostrum - Measured perpendicularly in front of the anterior premolars.
7. Cranial Breadth - Greatest breadth of braincase across the squamosal swellings behind the zygomatic arch.
8. Diastema Length - Posterior edge of I^2 to the anterior edge of P^3 at the alveolar borders.
9. Maxillary Tooth Row - Length of maxillary tooth row at the alveolar border.
10. Width of Rostrum - Width of rostrum at the anterior edge of P^3.
11. Zygoma Length - Maximum length of zygomatic arch.

12. Inion-Incisor Length - Posterior tip of inion (occiput) to posterior border of the alveolus of the incisors.
13. Greatest Length (II) - Anteriormost face of upper incisors to the posterior edge of external occipital protuberance.
14. Condylobasal Length - Posterior edge of occipital condyles to the anteriormost face of incisors.
15. Length of Incisive Foramen - Greatest length of incisive foramen.
16. Breadth across Auditory Bullae - Greatest distance across auditory bullae.
17. Zygomatic Breadth (II) - Greatest distance across maxilla portion of the zygomatic arch.
18. Interorbital Breadth (anterior) - Minimum distance between orbits measured at the anterior edge of the supraorbital process.
19. Interorbital Breadth (posterior) - Minimum distance between orbits measured at the posterior edge of the supraorbital process.
20. Length of Palatal Bridge - Greatest length of bony palate.
21. Breadth across Upper Molars - Width across upper molars from outside alveolar borders.
22. Greatest Length of Mandible - Posterior edge of mandible to anteriormost face of incisors.
23. Greatest Depth of Mandible - Top of articular to bottom of angle.
24. Incisor-Basisphenoid Length - Posterior border of the alveolus of the incisors to inferior edge of the basisphenoid.

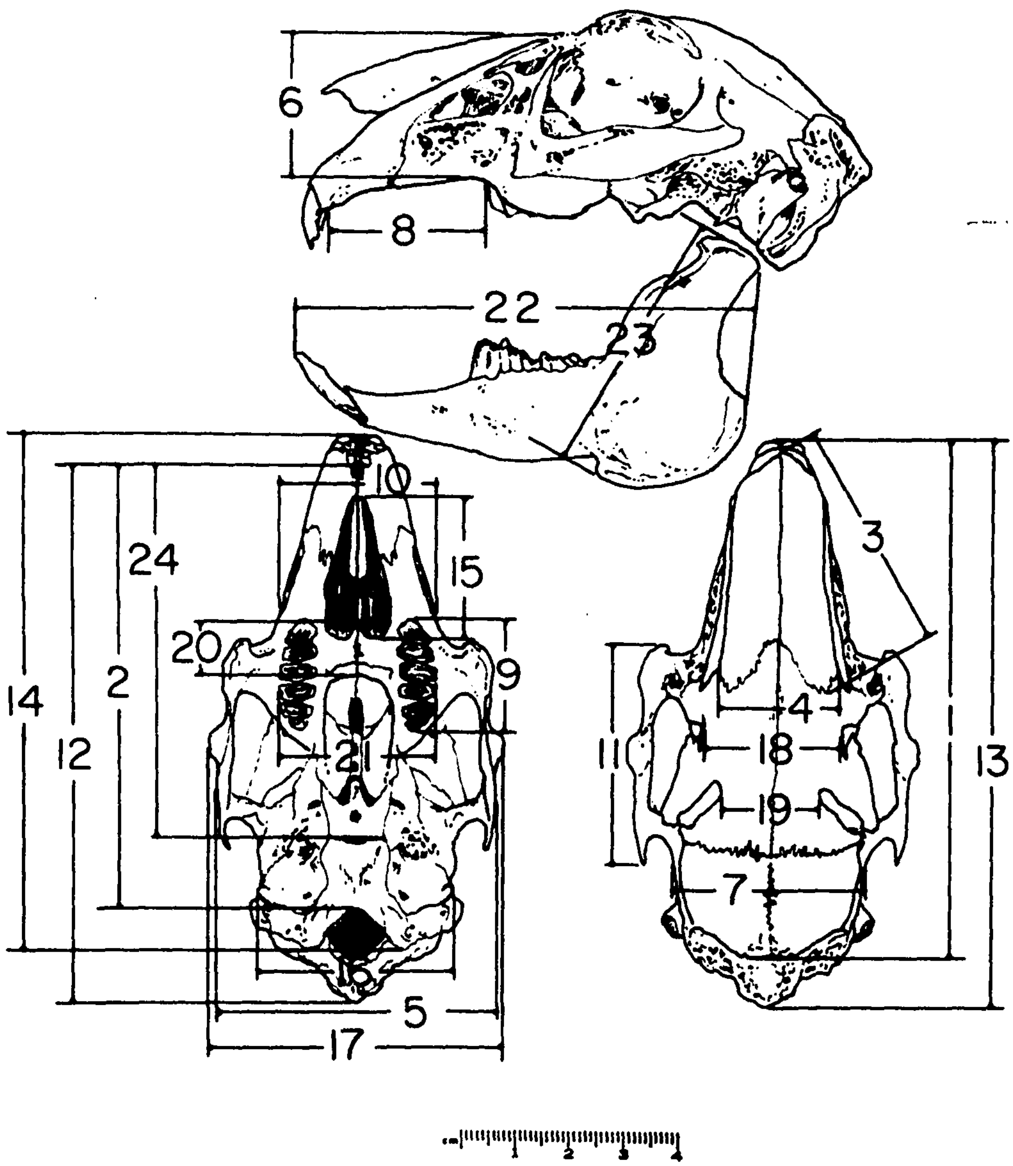


Figure 22. Skull measurements utilized in the systematic comparison.

APPENDIX 2, continued. Skull measurement data.

Skull No.	Measurement Numbers 1	2	3	4	5	6	7	8	9	10	11	12
1	99.4	76.2	43.1	22.3	50.0	26.6	33.9	28.1	19.0	23.2	42.2	96.7
2	101.4	80.3	42.3	20.9	51.1	26.0	26.5	30.7	19.5	25.7	43.6	100.4
3	101.7	80.7	45.0	22.4	52.6	28.7	35.3	21.8	19.0	27.8	43.6	101.4
4	94.9	74.6	38.4	21.8	49.1	26.3	34.3	26.9	18.3	26.8	41.9	92.9
5	99.8	79.8	43.3	22.6	51.7	26.4	34.3	29.4	20.4	27.4	44.8	98.5
6	93.7	75.2	39.5	20.0	51.5	25.9	34.5	27.1	18.2	27.2	41.8	93.2
7	79.3	61.5	30.0	17.7	46.0	21.0	31.7	22.4	14.6	23.7	33.9	79.1
8	78.0	60.5	30.1	17.0	45.9	21.1	32.9	22.2	14.5	22.6	33.3	78.1
9	102.7	83.6	44.8	22.9	53.0	27.8	36.0	31.8	19.7	27.3	45.3	-
10	99.1	78.0	41.5	23.1	50.0	26.6	35.1	27.8	19.3	25.3	43.3	98.2
11	102.6	83.3	42.8	24.0	52.1	26.3	35.3	30.3	18.9	26.9	46.3	102.5
12	101.9	80.2	43.8	22.8	51.5	28.4	34.3	29.4	19.0	27.1	45.3	100.0
13	-	-	-	-	-	-	33.3	-	-	-	-	-
14	97.6	78.8	42.7	22.6	51.8	26.8	34.8	29.3	18.5	26.0	42.4	97.8
15	102.9	83.8	45.9	-	52.7	28.2	36.8	31.0	20.8	28.2	45.4	102.4
16	102.4	84.1	45.6	22.0	51.6	29.0	36.0	29.9	19.7	27.6	45.4	101.5
17	99.3	79.7	44.3	21.1	51.1	25.5	35.1	29.4	19.2	26.4	44.1	98.8
18	-	-	42.7	20.3	-	25.3	-	30.2	19.1	27.2	-	-
19	96.7	-	37.4	-	51.0	25.6	34.5	27.9	18.6	26.3	41.5	-
20	99.6	79.6	-	18.6	51.1	25.6	25.6	29.2	18.7	25.1	43.3	98.7
21	102.6	83.0	43.2	22.1	51.0	28.0	34.2	30.6	19.5	26.6	45.9	101.8
22	98.9	79.4	42.6	21.4	52.2	26.1	34.8	29.2	18.8	24.8	44.7	98.8
23	100.3	80.7	-	-	51.8	-	34.8	30.2	19.1	24.2	44.3	100.4
24	99.7	81.2	41.6	20.3	51.1	25.3	33.5	30.3	19.2	24.7	43.1	99.0
25	-	81.8	43.5	21.1	52.5	27.5	35.5	30.9	18.9	26.4	44.9	99.7
26	105.7	85.3	45.0	23.8	52.9	29.5	35.2	31.5	20.9	29.1	45.5	105.5
27	102.6	-	43.0	-	52.5	27.9	35.8	29.5	20.2	25.3	45.1	-
28	100.7	80.7	39.2	21.3	52.6	26.9	35.0	29.4	19.4	25.7	43.2	100.2
29	100.5	80.5	43.9	20.8	51.4	25.9	34.3	30.0	19.2	26.1	44.0	99.9
30	100.2	-	41.4	21.5	51.2	27.1	33.8	29.2	19.8	27.3	44.7	-
31	101.6	84.1	-	19.8	50.6	27.5	34.7	30.3	19.8	27.3	43.5	101.9
32	102.5	83.2	44.4	20.1	53.1	27.3	36.8	30.9	19.5	26.2	44.2	103.5
33	101.9	-	41.4	21.5	52.2	26.3	35.6	29.4	19.9	25.6	46.0	-
34	100.1	79.1	41.0	-	52.8	26.4	36.8	28.7	19.9	26.1	44.2	98.8
35	101.3	81.1	43.4	22.2	51.2	26.2	36.2	29.7	20.3	26.2	44.8	100.5
36	100.5	-	40.6	22.3	52.2	25.4	35.5	28.4	20.0	25.0	43.8	-
37	101.1	82.3	42.0	20.4	53.0	27.2	37.0	28.6	20.0	25.7	45.0	99.9
38	100.3	80.4	42.8	21.1	51.5	27.0	35.2	29.9	19.3	26.8	43.7	99.9

APPENDIX 2, continued.

Skull No.	1	2	3	4	5	6	7	8	9	10	11	12
39	99.9	80.0	40.7	21.6	51.0	27.1	34.4	29.3	19.9	26.8	42.4	98.7
40	100.9	81.1	42.4	21.0	52.9	26.3	35.0	29.5	19.7	25.5	44.3	99.8
41	101.5	82.1	43.5	21.0	51.9	26.1	36.5	30.2	19.8	25.9	41.9	100.5
42	101.9	81.9	44.0	23.6	52.3	27.9	35.5	29.7	19.8	26.8	44.7	102.3
43	104.2	83.5	43.3	23.9	51.8	26.9	36.6	31.2	19.5	28.3	45.1	102.2
44	100.2	-	43.8	22.0	49.9	25.9	33.7	29.1	19.1	26.6	44.0	-
45	102.9	83.6	44.2	24.4	53.3	26.3	35.7	29.5	20.9	27.8	46.5	103.1
46	101.2	81.0	-	22.0	52.2	27.5	36.1	29.1	19.9	25.9	32.6	100.1
47	101.1	79.6	43.5	21.2	50.3	27.6	35.5	29.0	19.0	26.2	43.9	98.7
48	103.0	82.8	45.3	24.4	52.4	27.3	37.2	30.0	19.5	26.8	44.5	101.8
49	104.4	85.7	-	-	51.2	-	35.6	31.0	20.5	28.0	44.6	105.3
50	103.3	83.4	44.1	19.0	50.7	26.1	35.0	29.5	19.5	24.8	44.5	102.7
51	101.3	80.6	41.4	22.8	51.2	26.2	35.3	30.0	19.6	25.6	41.9	100.6
52	99.2	79.1	41.3	21.6	50.9	27.9	34.4	29.3	19.6	26.1	42.9	98.9
53	100.0	82.0	40.1	-	51.5	26.3	34.6	29.2	19.7	25.4	45.4	100.9
54	99.7	80.6	-	21.9	50.5	27.0	35.5	28.8	19.5	24.7	42.8	99.4
55	100.3	79.0	40.0	20.0	50.3	27.5	34.0	28.6	20.1	27.1	43.2	98.4
56	101.0	-	-	-	52.0	-	34.9	28.9	20.2	25.8	44.6	-
57	100.5	79.1	42.3	20.4	50.3	25.4	24.8	28.9	19.5	25.8	43.0	99.5
58	101.9	83.4	-	-	51.5	27.8	35.9	30.1	19.7	26.5	44.7	102.7
59	100.8	81.7	41.7	22.0	51.5	26.7	34.6	29.8	19.2	28.0	44.0	100.3
60	97.7	80.4	43.3	20.3	51.2	26.6	35.4	30.6	19.8	27.0	42.2	98.1
61	103.1	84.1	-	-	51.8	-	35.4	31.0	19.7	27.4	43.8	103.9
62	103.0	84.6	42.3	22.5	51.7	27.9	35.0	30.7	20.1	28.7	46.0	103.0
63	99.7	79.8	41.3	21.7	50.4	26.4	35.2	29.0	19.1	25.4	42.8	98.8
64	100.6	81.3	-	21.0	51.5	27.5	35.2	29.9	18.8	26.1	44.4	100.8
65	99.6	79.5	40.8	22.1	50.9	26.7	34.3	28.9	19.2	26.1	43.9	99.2
66	101.5	81.1	41.0	21.9	51.2	27.8	34.4	28.5	20.1	25.2	45.3	101.2
67	99.3	78.5	-	-	51.0	-	35.4	27.8	18.9	25.0	42.3	98.2
68	101.7	82.0	43.2	21.0	52.3	26.4	35.3	28.4	20.1	24.7	46.6	101.8
69	104.1	85.0	45.0	23.0	52.5	28.4	36.0	31.0	20.6	28.0	44.9	103.5
70	101.5	83.8	-	-	50.8	-	36.1	29.9	20.0	27.5	42.9	102.6
71	103.4	83.4	44.8	21.2	51.1	27.3	35.3	30.2	19.8	25.1	44.6	103.2
72	105.3	85.4	44.5	-	53.7	28.6	35.6	30.8	21.5	27.9	46.3	105.2
73	100.4	80.5	40.6	20.4	51.3	27.2	35.1	29.6	19.3	27.3	44.4	99.9
74	102.5	-	40.6	21.7	51.0	25.3	35.2	28.9	20.0	25.5	44.3	-
75	101.3	79.1	44.1	21.5	53.8	27.3	38.4	28.5	19.5	28.9	44.0	99.6

APPENDIX 2, continued.

Skull No.	1	2	3	4	5	6	7	8	9	10	11	12
76	102.3	83.0	42.2	21.3	51.2	27.7	35.0	30.7	20.0	27.6	43.5	101.3
77	95.4	74.5	-	-	49.5	24.3	34.9	27.5	19.0	22.5	40.3	95.3
78	103.5	83.7	38.6	-	51.9	26.5	36.8	30.7	19.4	27.2	44.3	103.9
79	101.9	83.0	41.7	20.7	52.1	26.8	36.9	29.6	19.9	27.7	45.9	101.8
80	86.6	68.7	35.8	18.4	47.9	23.3	33.4	24.4	16.5	21.8	37.9	86.2
81	102.3	82.1	44.1	21.9	50.5	27.1	34.2	31.7	18.5	26.3	44.8	101.7
82	101.8	80.9	45.3	20.6	51.6	28.1	35.8	30.3	20.0	25.9	43.6	100.9
83	77.6	59.8	27.1	16.0	43.6	20.0	32.3	20.7	15.3	21.1	33.0	76.1
84	87.4	69.6	36.5	20.5	48.2	23.8	32.9	24.9	16.1	23.9	38.8	86.7
85	88.6	69.4	35.9	19.1	49.4	22.9	35.6	24.8	16.4	23.6	29.0	88.3
86	87.1	68.1	33.3	-	47.2	15.5	32.9	24.3	16.2	16.0	38.0	86.9
87	-	-	42.5	22.6	-	27.3	-	29.1	19.9	29.3	44.8	-
88	98.7	78.4	38.1	22.0	50.4	26.5	35.6	28.2	19.1	27.4	42.3	97.2
89	96.6	78.8	-	23.1	52.5	26.8	35.4	29.0	19.4	29.0	42.2	97.2
90	99.3	78.0	41.7	21.1	52.3	26.7	36.9	26.6	19.2	24.9	44.4	97.7
91	103.4	82.5	43.4	22.9	-	27.9	35.6	29.6	20.0	28.9	43.7	102.7
92	98.5	78.1	40.1	21.6	49.0	37.7	33.3	28.1	19.1	25.8	42.7	96.5
93	96.2	78.1	40.0	21.2	49.7	25.2	33.5	28.2	18.8	25.5	40.8	95.5
94	98.7	78.0	39.2	21.6	51.4	25.7	34.2	28.6	19.2	27.1	43.3	97.7
95	93.9	74.6	40.8	-	44.7	-	32.0	28.6	17.5	23.8	37.3	93.1
96	97.0	78.2	38.4	-	51.8	27.5	35.0	27.9	19.5	25.6	43.1	97.1
97	99.6	81.1	42.8	21.6	50.3	26.6	34.2	28.8	19.6	25.7	42.9	99.5
98	95.0	-	39.5	20.4	51.0	24.6	35.1	26.8	19.0	24.6	40.8	93.8
99	95.7	77.8	40.3	20.6	51.3	26.7	34.0	26.2	19.1	24.9	42.5	96.3
100	98.3	77.1	40.9	21.7	50.6	27.2	35.7	27.9	19.3	26.8	43.7	97.1
101	100.7	83.0	42.4	21.4	51.3	27.8	36.0	28.9	19.6	26.3	45.4	100.0
102	-	-	41.3	20.7	-	25.8	35.1	28.3	19.3	25.1	44.1	-
103	104.3	83.9	41.7	24.1	52.9	28.7	36.6	30.2	20.8	25.6	45.7	103.7
104	86.5	-	-	17.7	48.7	22.9	33.1	26.1	17.0	22.8	35.0	-
105	100.6	81.6	41.8	21.3	50.7	25.8	34.7	30.1	19.1	27.2	43.9	100.4
106	100.6	79.5	43.9	22.9	52.1	27.9	36.3	30.2	19.2	27.2	42.2	99.2
107	98.4	76.9	43.8	21.6	51.1	25.9	35.5	28.2	18.9	25.3	43.1	97.8
108	100.0	-	45.1	21.3	51.1	26.4	35.6	29.0	20.0	24.6	44.0	-
109	95.8	77.1	42.4	22.3	49.8	26.1	35.3	27.6	18.5	24.3	41.5	95.3
110	96.1	77.4	-	22.9	51.5	25.8	36.5	27.5	18.8	25.4	41.6	95.9
111	98.1	80.4	42.5	22.6	51.8	26.5	36.0	29.3	18.7	26.6	42.2	97.6
112	100.5	77.0	-	21.4	51.3	25.7	35.8	30.2	17.6	27.1	43.4	97.5
113	100.7	79.3	44.8	22.8	51.3	28.9	34.8	29.7	19.7	29.4	44.0	99.2

APPENDIX 2, continued.

Skull No.	1	2	3	4	5	6	7	8	9	10	11	12
114	100.2	80.5	40.3	21.9	52.2	25.0	35.0	30.0	18.7	26.6	43.4	100.1
115	103.9	82.6	44.6	21.0	50.3	27.5	35.3	30.3	20.6	27.5	42.9	103.3
116	99.0	77.2	37.2	21.6	51.8	25.7	35.6	28.7	19.3	26.8	42.3	97.8
117	99.6	79.4	-	24.0	51.0	27.4	33.9	28.2	19.0	28.1	45.1	98.7
118	96.5	77.2	37.6	20.1	49.7	25.7	33.7	27.4	19.4	24.4	41.6	94.4
119	100.6	78.3	43.2	22.7	53.1	28.1	35.2	27.7	19.1	27.8	42.3	97.8
120	100.8	78.3	43.6	21.3	51.5	27.6	36.1	28.9	20.3	26.4	42.9	98.4
121	98.1	77.4	42.2	22.5	50.1	27.5	34.2	28.3	18.9	25.6	42.6	96.6
122	98.2	77.5	45.0	22.4	51.0	26.0	35.9	27.5	18.9	24.3	42.3	96.4
123	97.9	79.9	42.2	21.4	49.1	27.3	33.1	29.2	19.5	27.0	43.5	97.2
124	98.7	77.9	40.4	19.5	51.5	26.2	34.5	28.1	19.0	23.8	41.3	96.5
125	97.7	77.3	38.4	21.5	51.5	25.7	34.6	28.9	18.6	25.0	40.9	97.0
126	104.9	83.7	44.6	23.3	53.4	27.8	36.7	30.8	20.2	27.9	44.4	103.5
127	103.1	-	44.8	22.3	51.9	28.6	35.0	29.9	-	28.0	44.6	103.2
128	101.3	-	44.0	21.7	52.3	27.5	35.6	30.2	19.9	28.5	44.2	100.0
129	97.1	76.9	41.1	22.2	52.3	25.8	36.8	27.7	19.2	26.0	42.2	95.3
130	99.0	79.5	42.2	22.1	52.1	27.4	36.1	28.3	19.9	26.1	43.0	97.7
131	96.2	75.3	41.3	21.4	49.2	26.1	34.2	27.5	18.3	24.3	42.1	93.0
132	99.5	79.1	45.7	21.5	51.8	27.7	36.3	29.3	19.0	24.3	43.2	98.6
133	-	-	-	19.4	49.7	23.0	-	27.3	18.3	22.9	49.1	-
134	-	-	-	20.4	-	25.6	-	28.0	19.2	26.4	-	-
135	85.3	66.7	-	-	48.4	-	32.4	23.8	16.5	21.3	-	85.0
136	97.1	76.2	39.1	21.0	49.8	25.4	36.2	26.8	19.5	24.7	42.2	95.4
137	93.1	73.5	38.7	20.0	49.3	23.4	33.5	25.8	18.0	23.1	40.2	92.4
138	97.7	78.7	42.7	21.7	51.4	25.0	36.8	27.1	19.3	23.5	41.7	96.6
139	95.3	76.1	39.1	18.9	49.4	26.0	32.9	27.2	18.7	24.5	41.7	94.7
140	90.2	71.4	36.0	18.5	49.1	24.2	33.5	24.4	19.3	23.0	39.2	89.1
141	95.9	75.8	38.0	19.1	50.4	24.1	35.5	27.0	18.3	26.0	41.0	94.7
142	96.0	76.1	38.5	21.2	51.2	25.3	35.2	26.7	19.4	23.8	41.8	94.9
143	92.2	73.7	38.0	19.4	47.9	23.2	33.3	25.8	19.0	22.9	40.4	91.0
144	97.1	76.5	40.9	20.8	49.0	25.4	33.4	27.2	20.2	23.9	40.6	95.9
145	97.1	78.6	41.4	21.9	49.6	25.2	35.0	27.8	19.5	24.2	42.8	96.5
146	100.0	81.7	43.8	21.7	49.3	28.7	34.6	28.5	20.1	26.2	43.9	99.8
147	98.2	77.5	40.8	20.1	-	25.8	33.2	28.3	18.5	24.5	40.9	96.7
148	96.1	74.5	38.9	21.2	49.2	28.5	34.9	26.9	18.9	25.8	40.7	93.2
149	94.9	75.8	37.1	18.8	49.9	25.6	34.0	26.9	18.1	24.3	40.8	94.0
150	101.5	79.5	41.9	23.9	52.5	27.4	36.1	28.7	20.0	27.6	44.0	99.1

APPENDIX 2, continued.

Skull No.	1	2	3	4	5	6	7	8	9	10	11	12
151	41.2	28.9	10.0	8.0	26.7	9.0	24.8	9.2	8.0	12.4	14.1	38.6
152												
153												
154												
155												
156												
157												
158												
159												
160												
161	106.3	84.1	46.3	22.1	51.7	26.8	33.6	32.2	19.5	27.7	47.2	105.7
162	99.9	80.7	42.0	22.0	51.3	26.5	34.1	30.1	19.3	27.4	43.2	100.2
163	101.4	81.8	41.2	22.2	51.6	25.7	35.5	29.6	19.8	27.0	42.6	101.0
164	103.0	82.8	42.6	23.2	53.8	27.6	35.6	30.4	20.5	27.0	44.1	101.3
165	99.2	78.7	41.9	19.9	50.8	25.7	35.5	28.0	19.8	24.6	41.7	98.5
166	104.0	84.4	44.0	24.4	51.6	25.9	36.2	30.8	21.3	26.9	-	103.6
167												
168												
169												
170												
171	105.3	87.3	44.5	22.3	52.7	26.0	34.8	31.8	19.7	27.7	43.7	106.4
172	101.3	81.5	-	-	50.5	-	34.5	29.3	19.9	25.2	44.0	100.5
173	-	-	41.4	21.9	52.5	26.0	-	30.4	20.1	26.0	44.8	-
174	-	78.7	37.8	20.0	51.2	27.5	34.4	28.1	19.3	25.4	43.6	95.6
175												
176												
177												
178												
179												
180												
181												
182												
183												
184												
185												
186												
187												
188												
189												

APPENDIX 2, continued.

Skull No.	13	14	15	16	17	18	19	20	21	22	23	24
1	103.0	89.9	24.7	34.6	-	27.6	17.6	9.8	29.8	80.0	52.0	64.4
2	105.5	92.8	26.3	35.9	54.5	24.6	17.6	11.8	30.7	82.6	51.6	68.3
3	106.8	93.9	27.8	35.0	52.9	26.1	18.6	9.2	30.5	82.4	50.4	68.7
4	98.7	88.0	23.0	33.3	49.3	25.7	17.6	10.3	29.9	26.4	49.0	62.2
5	103.9	92.2	25.5	33.6	54.5	27.2	16.0	11.5	30.2	81.0	53.0	67.3
6	98.0	87.2	23.6	32.9	50.5	25.3	18.3	11.1	27.8	74.8	50.3	63.4
7	82.9	73.0	18.9	30.1	44.3	22.0	16.6	9.6	24.4	63.2	41.0	52.4
8	81.6	71.0	19.8	30.3	43.2	21.1	15.7	9.2	23.6	62.9	41.2	51.3
9	-	97.7	27.2	34.2	54.8	27.1	16.7	12.3	30.9	84.9	55.1	71.6
10	104.4	91.8	23.9	31.3	51.4	27.2	16.4	11.6	29.1	79.6	51.5	66.0
11	109.2	97.2	26.5	33.8	54.3	25.6	15.7	11.0	30.0	85.1	54.9	71.2
12	106.3	94.6	26.1	33.5	52.8	28.2	18.1	11.9	28.5	83.3	55.2	67.3
13	-	-	-	32.8	-	-	18.2	-	-	82.8	52.2	-
14	102.9	92.0	26.8	31.6	53.5	25.9	15.5	11.5	28.5	81.3	50.5	66.7
15	108.7	97.1	27.9	35.0	55.5	26.1	15.3	9.7	29.1	85.1	53.1	69.8
16	107.7	97.2	25.6	33.7	53.5	27.4	16.8	11.2	29.4	84.7	54.4	70.4
17	104.3	93.6	25.3	34.0	53.2	24.8	16.6	10.9	28.5	80.6	51.4	67.5
18	-	-	27.5	-	-	23.8	-	10.1	29.6	83.0	50.4	-
19	-	-	25.2	-	53.6	25.5	17.0	11.0	29.0	79.2	49.6	65.0
20	104.1	92.9	24.9	34.7	53.1	25.7	17.6	11.1	28.3	80.5	50.7	67.3
21	108.0	96.2	27.6	33.1	55.5	27.0	15.7	10.7	29.3	83.1	53.9	69.0
22	104.5	93.1	24.9	32.7	53.0	26.4	17.1	11.8	29.2	81.2	51.3	66.5
23	105.9	94.0	27.2	34.9	54.3	27.1	18.8	9.5	29.7	80.2	50.5	67.9
24	105.0	94.7	27.2	32.6	52.0	24.1	16.6	11.2	28.7	80.9	50.9	68.7
25	-	-	26.1	33.0	54.0	26.0	18.0	13.0	30.0	-	53.4	69.4
26	112.1	99.3	27.4	35.2	56.7	28.3	16.1	10.7	30.8	86.1	54.6	71.1
27	-	-	27.4	-	54.7	24.3	16.8	9.9	30.2	83.6	54.3	69.5
28	106.2	94.4	26.4	34.1	53.2	27.4	17.3	10.3	29.1	82.9	52.6	68.2
29	106.1	94.6	25.6	33.5	52.3	25.4	16.3	10.7	28.2	81.1	50.4	68.5
30	-	-	26.3	-	51.4	24.2	14.5	10.1	31.1	83.0	52.9	68.7
31	107.8	97.7	27.5	34.9	52.6	23.3	17.0	10.5	29.0	83.1	53.2	70.9
32	109.0	98.0	27.4	35.8	54.1	24.8	16.7	11.5	29.5	84.8	52.8	71.5
33	-	-	27.4	-	53.5	27.3	15.3	10.5	29.3	81.0	50.8	69.0
34	104.5	92.9	25.3	36.7	-	25.3	15.3	11.2	29.6	80.5	53.2	67.0
35	105.8	94.4	26.9	34.2	53.6	25.5	17.1	10.6	28.5	81.9	50.6	69.3
36	-	-	25.8	-	54.2	27.6	17.4	10.1	29.8	82.5	52.6	66.7
37	106.9	95.8	26.1	35.8	54.3	26.2	15.6	11.3	30.1	81.5	54.0	68.8
38	106.7	94.0	26.2	34.2	53.6	26.8	17.0	10.9	28.6	83.1	49.8	67.0

APPENDIX 2, continued.

Skull No.	13	14	15	16	17	18	19	20	21	22	23	24
39	104.8	92.7	26.2	34.7	53.8	27.4	17.4	10.7	27.8	80.0	50.2	67.4
40	105.4	94.3	25.9	32.4	56.0	24.3	15.8	10.1	30.4	83.5	52.8	67.9
41	106.6	95.4	27.2	33.9	53.8	25.4	16.9	10.5	29.1	83.9	50.9	69.4
42	108.0	96.7	27.2	34.2	56.5	28.4	17.4	11.5	29.1	82.0	52.1	68.7
43	108.7	96.7	27.0	35.2	56.8	22.7	16.5	10.9	30.9	85.6	53.1	70.4
44	-	-	25.8	-	53.1	24.8	15.6	9.8	29.9	82.2	52.0	67.1
45	108.9	97.3	25.6	35.2	56.1	29.1	16.9	10.7	30.3	84.1	53.4	70.0
46	105.8	94.5	25.8	33.1	53.4	27.3	16.0	10.8	30.0	81.6	51.1	68.4
47	104.2	93.0	26.4	-	52.0	23.7	15.5	11.9	29.4	79.8	50.3	68.1
48	108.1	97.1	27.5	35.4	55.6	28.4	16.5	10.8	29.6	82.4	52.9	70.2
49	111.3	99.9	26.6	34.6	54.6	25.6	17.3	10.8	30.6	85.7	52.8	72.0
50	108.2	96.7	26.7	34.4	52.9	25.6	17.7	10.5	29.9	84.3	52.3	71.2
51	106.4	95.2	27.0	33.9	52.9	26.2	18.0	11.9	30.1	82.5	50.9	70.0
52	104.6	93.4	26.4	33.0	-	25.1	15.9	11.1	28.6	78.9	52.3	66.7
53	106.1	95.0	27.3	32.8	55.1	26.1	16.4	9.0	29.9	81.4	53.3	70.0
54	105.0	94.1	26.5	33.9	51.9	26.2	17.6	11.7	28.2	80.8	49.3	68.4
55	104.3	93.1	25.9	35.0	51.8	23.4	16.8	12.0	30.9	81.9	51.8	66.6
56	-	-	25.9	-	54.4	26.9	18.7	9.9	29.3	80.3	53.5	68.5
57	105.1	93.1	25.5	33.4	52.2	22.8	16.4	10.7	29.0	80.6	52.0	67.4
58	108.2	97.0	27.4	34.2	54.8	26.3	17.2	11.2	28.8	83.3	52.9	70.6
59	106.0	94.6	26.3	34.1	54.0	23.9	15.2	11.2	30.1	83.5	52.1	68.8
60	103.6	93.0	27.0	31.9	52.8	23.0	15.2	12.2	28.5	82.9	51.7	68.9
61	109.2	97.6	28.4	33.5	55.5	29.7	18.8	11.7	29.8	84.9	51.4	71.3
62	109.2	98.1	26.9	34.5	54.6	26.7	16.2	9.9	29.9	84.6	54.2	70.7
63	104.9	93.4	25.6	32.3	51.5	25.5	16.4	11.9	29.2	80.7	50.2	67.2
64	106.2	94.9	25.7	34.4	53.5	27.0	18.0	12.2	29.6	83.7	52.5	68.9
65	104.9	93.3	25.4	32.4	52.7	26.8	16.6	11.3	30.3	81.2	51.0	67.7
66	107.2	95.2	25.4	34.6	-	26.0	16.8	12.3	29.8	81.1	52.5	68.5
67	103.7	92.1	25.1	32.3	51.9	25.3	17.1	11.7	28.6	79.8	48.2	66.7
68	107.9	96.0	25.4	33.8	53.0	26.6	17.4	12.2	30.4	83.9	53.0	69.8
69	109.3	98.2	27.6	34.1	56.2	27.3	17.5	11.3	30.3	86.1	52.6	71.8
70	107.7	97.2	27.7	35.0	53.8	25.2	16.6	9.5	29.4	81.6	51.2	69.5
71	109.1	97.7	26.8	33.3	55.1	26.5	17.4	12.0	28.8	81.1	51.1	70.2
72	111.5	99.3	27.3	35.9	-	26.6	16.6	12.0	31.1	85.4	54.9	71.8
73	105.8	94.0	26.5	34.2	53.8	25.6	16.1	9.3	29.8	81.1	52.9	67.6
74	-	-	25.5	-	52.2	24.5	15.5	11.3	29.8	83.2	53.2	69.1
75	105.4	93.3	26.1	33.9	53.8	25.2	17.6	10.3	29.6	81.6	53.3	67.5

APPENDIX 2, continued.

Skull No.	13	14	15	16	17	18	19	20	21	22	23	24
76	107.7	97.1	27.0	-	53.8	26.9	16.9	10.2	29.8	-	-	70.2
77	100.4	88.0	25.8	33.2	50.0	23.2	15.5	9.8	28.1	74.9	48.1	63.3
78	109.3	97.4	27.1	35.2	54.2	24.1	15.9	11.8	29.8	83.9	52.9	71.0
79	107.7	96.0	26.6	34.1	54.9	26.1	16.8	11.1	29.2	83.7	52.3	69.5
80	89.9	79.2	21.2	32.0	45.6	21.7	16.9	10.0	25.0	70.5	44.3	57.3
81	107.1	95.0	26.8	33.4	52.1	26.9	18.0	10.9	29.6	84.1	51.3	70.2
82	106.3	94.7	27.6	34.1	51.8	23.2	16.2	10.2	25.9	80.6	53.2	68.7
83	80.2	71.6	18.0	31.1	42.1	19.1	15.5	9.8	23.8	61.6	39.2	50.8
84	91.0	80.8	22.0	34.2	46.8	23.9	17.0	10.5	27.2	72.0	46.2	58.6
85	92.8	81.4	21.6	34.0	47.9	23.5	16.0	10.2	27.9	71.1	45.4	58.8
86	91.5	80.4	22.7	33.1	46.2	23.3	17.2	9.6	26.3	70.3	46.0	57.3
87	-	-	25.7	-	-	26.6	16.3	10.9	29.7	-	-	-
88	103.2	92.3	25.0	35.1	52.0	26.1	18.6	11.1	30.3	80.8	49.9	66.5
89	102.4	91.5	26.8	34.5	56.9	-	17.3	10.2	28.7	80.2	53.6	66.3
90	103.8	91.4	23.4	33.6	52.9	23.7	17.0	9.5	30.2	81.5	53.2	65.5
91	108.8	97.1	26.3	34.9	-	28.0	16.7	10.6	28.5	83.7	51.9	70.3
92	102.1	90.8	24.7	30.6	49.8	26.4	16.5	10.4	28.0	78.5	51.8	65.8
93	100.7	90.6	25.8	31.4	50.9	25.4	16.2	9.4	28.6	80.3	52.2	66.5
94	103.2	90.7	24.5	33.8	52.5	25.6	17.2	11.4	29.6	77.9	49.3	66.2
95	97.6	87.1	25.8	30.6	44.4	19.8	12.2	8.4	25.0	72.2	44.0	63.9
96	102.2	91.2	25.5	31.4	52.2	25.9	15.3	9.2	28.6	-	-	65.8
97	105.2	95.0	26.3	32.9	52.8	26.9	17.5	11.2	29.1	82.0	52.0	67.9
98	98.7	-	21.3	-	51.3	24.2	18.0	10.7	29.3	77.7	45.9	-
99	101.6	90.1	23.4	31.0	53.8	26.7	16.8	9.6	29.7	78.9	50.1	65.5
100	102.7	90.4	25.0	34.8	52.0	25.9	15.3	10.9	30.1	78.8	50.1	65.3
101	106.1	94.6	26.6	32.9	53.8	28.3	16.3	10.4	25.9	81.6	52.8	68.7
102	-	-	24.6	-	-	24.2	16.3	10.6	28.6	-	-	66.4
103	111.1	99.0	25.2	33.2	56.9	29.6	17.0	12.0	29.3	86.7	56.0	70.8
104	92.4	-	23.4	-	48.2	22.1	15.6	9.0	26.5	-	-	-
105	106.6	94.5	33.9	-	-	26.0	15.8	11.3	28.9	81.4	51.7	68.9
106	105.2	93.6	26.9	35.7	54.0	27.0	17.8	11.4	29.4	82.9	52.1	67.5
107	103.4	91.1	24.1	34.0	53.0	26.7	15.6	11.2	30.1	80.2	53.5	64.5
108	-	-	24.8	35.1	52.5	26.2	16.0	12.3	30.8	82.0	54.6	68.0
109	100.6	90.0	25.3	32.4	49.0	27.4	15.5	9.7	28.3	79.3	50.2	65.8
110	101.2	90.5	24.1	34.3	52.3	28.8	17.6	12.0	28.7	78.7	50.1	64.7
111	103.3	93.0	25.5	33.4	54.5	26.6	17.6	11.4	28.3	79.5	51.8	68.1
112	103.6	91.2	24.5	33.4	50.8	25.3	17.6	11.9	29.8	81.5	53.5	66.4
113	105.0	92.9	25.9	34.4	53.2	26.7	15.9	11.9	31.6	83.8	55.7	67.5

APPENDIX 2, continued.

Skull No.	13	14	15	16	17	18	19	20	21	22	23	24
114	105.8	93.3	25.7	35.3	54.7	25.0	15.2	10.7	27.8	81.2	54.1	67.5
115	108.9	96.7	27.0	34.0	54.6	24.1	15.5	10.2	29.2	83.9	51.3	70.4
116	104.4	91.6	24.2	34.5	-	26.3	15.5	10.1	31.2	-	54.0	65.5
117	104.4	93.1	23.1	32.1	53.3	27.9	16.1	10.7	31.0	82.2	54.8	66.2
118	102.2	90.7	23.8	31.9	49.4	25.2	14.9	10.6	30.0	78.5	49.9	64.4
119	104.5	92.0	24.5	35.4	54.3	27.0	17.5	9.5	31.8	81.0	51.8	65.9
120	104.0	91.8	25.9	33.4	53.1	24.4	15.5	12.5	29.6	79.6	53.8	66.9
121	102.1	90.9	24.8	33.6	52.0	25.8	16.9	10.6	29.7	80.8	52.8	65.4
122	102.0	91.0	24.1	32.9	51.8	26.8	19.3	12.0	28.9	79.7	52.2	65.6
123	103.1	93.5	24.9	31.8	52.0	23.0	15.1	10.2	28.5	80.9	52.1	67.4
124	102.4	90.4	23.7	31.8	51.3	23.8	15.4	11.5	29.3	80.3	52.1	65.8
125	102.3	90.2	24.7	31.4	51.2	26.0	15.4	11.6	29.9	79.1	51.1	65.6
126	111.3	97.4	26.9	35.0	55.8	27.9	16.0	11.1	31.5	86.6	54.0	71.2
127	109.1	-	-	-	55.1	27.9	17.1	-	-	82.2	54.5	-
128	106.2	94.6	27.4	33.4	55.4	26.2	16.7	12.0	30.7	82.8	51.8	68.8
129	101.9	90.4	24.4	33.0	53.5	28.0	19.6	10.3	30.3	78.7	53.1	66.0
130	104.4	92.6	25.1	34.8	53.6	25.8	16.5	10.4	25.9	80.9	51.1	66.5
131	99.4	88.2	23.8	31.8	49.6	24.4	15.5	10.5	29.0	77.8	51.5	63.9
132	104.2	93.1	26.6	33.5	51.7	25.6	18.2	11.2	28.9	79.3	54.5	67.7
133	-	-	23.8	-	49.5	25.1	17.6	10.7	29.1	76.5	47.5	64.1
134	-	-	25.4	-	-	24.2	-	8.9	-	-	-	-
135	89.5	78.5	21.6	-	47.2	23.0	15.9	10.2	26.4	69.0	43.9	56.4
136	101.8	90.2	23.7	34.5	52.1	25.4	17.8	9.8	28.7	80.0	48.7	64.8
137	97.5	86.6	23.7	30.4	51.4	23.5	17.1	10.7	28.6	75.3	48.0	62.6
138	102.0	91.2	24.3	32.1	53.6	25.6	18.1	10.1	28.1	77.8	49.1	66.8
139	100.6	89.9	23.9	31.0	52.3	22.9	16.1	9.7	28.1	78.2	50.5	64.5
140	94.2	84.2	22.3	34.9	48.5	21.9	15.8	9.0	27.2	72.6	48.1	60.2
141	100.3	89.0	24.5	33.8	53.1	22.8	16.5	9.9	29.2	77.1	48.2	64.7
142	101.0	89.6	25.3	34.0	52.3	26.0	18.5	9.8	29.6	79.2	49.3	64.1
143	96.4	85.8	23.2	32.1	48.5	22.6	16.6	11.0	27.2	72.7	46.5	62.3
144	101.7	90.6	25.1	33.2	51.2	24.9	16.6	10.2	28.8	77.5	50.0	64.7
145	102.2	91.5	24.9	34.2	52.2	23.8	17.0	9.2	29.7	79.6	51.0	65.9
146	105.9	94.8	25.7	33.9	52.3	25.7	15.5	10.5	28.6	82.1	51.3	68.3
147	102.6	90.8	24.7	32.5	-	23.1	16.3	9.0	29.0	79.3	48.6	65.7
148	99.8	88.0	23.9	31.8	50.9	25.7	18.1	9.7	26.5	78.1	49.2	62.2
149	99.7	87.8	23.9	31.5	50.0	22.5	15.4	10.2	27.7	76.9	49.7	64.8
150	105.7	93.8	25.6	33.5	55.1	30.4	16.0	8.3	31.6	82.0	53.2	67.5

APPENDIX 2, continued.

Skull No.	13	14	15	16	17	18	19	20	21	22	23	24
151	41.0	34.7	7.3	17.7	25.3	10.5	13.0	5.5	13.4	26.1	15.8	23.4
152												
153												
154												
155												
156												
157												
158												
159												
160												
161	111.2	97.8	26.9	34.5	55.6	25.2	16.6	11.0	30.4	86.5	53.3	72.6
162	105.9	93.4	26.1	32.9	52.8	27.8	17.2	10.7	30.1	81.9	52.0	68.2
163	106.9	95.3	26.0	34.6	52.1	25.4	16.3	11.3	29.7	83.8	52.6	68.3
164	108.6	96.4	27.0	35.3	54.8	28.9	16.2	11.6	30.7	85.5	54.8	69.8
165	104.3	92.3	24.9	34.8	52.3	23.5	16.0	10.7	29.8	81.0	51.8	67.0
166	110.0	98.5	27.4	34.6	-	26.3	17.5	10.9	29.6	-	-	72.1
167												
168												
169												
170												
171	111.9	99.9	28.3	35.3	55.0	27.9	17.8	10.2	29.3	82.2	51.8	73.7
172	106.7	95.7	26.8	34.2	53.0	26.5	16.1	10.8	27.9	84.0	51.5	69.2
173	-	-	27.2	-	55.2	26.1	16.6	12.2	30.0	87.0	51.3	-
174	-	-	25.7	34.5	51.9	25.4	16.9	10.9	29.2	79.7	49.3	-
175												
176												
177												
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189												

APPENDIX 3. Comparison of the body measurements of the three populations of *Lepus othus*.

Population	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Weight		
LOIII	4774.0	500.7	60.3	69	3900-6492
LOII	4922.1	710.2	197.0	13	3969-6294
LOI					
			Total Length		
LOIII	659.9	19.7	3.1	39	580-689
LOII	667.7	15.4	4.4	12	635-690
LOI	592.3	20.4	11.8	3	570-610
			Tail Length		
LOIII	71.2	13.5	2.4	33	44-114
LOII	70.5	13.2	3.8	12	56-104
LOI	51.0	23.6	11.8	4	25-76
			Hind Foot Length		
LOIII	187.0	5.8	0.7	72	169-197
LOII	179.5	5.9	1.6	14	164-189
LOI	166.0	9.4	4.7	4	152-172
			Ear From Notch		
LOIII	91.4	4.6	0.5	72	82-114
LOII	91.2	6.5	2.1	10	82-102
LOI					
			Body Length		
LOIII	602.0	19.3	2.4	64	568-643
LOII	599.7	17.2	5.4	10	565-622
LOI	523.7	27.0	15.6	3	505-559

LOIII = Northern Population

LOII = Central Population

LOI = Southern Population

APPENDIX 4. Comparison of the 24 skull measurements of the three populations of *Lepus othus*.

Population	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Greatest Length (I)		
LOIII	101.38	1.99	0.22	80	95.4-106.3
LOII	99.10	2.25	0.36	40	94.9-104.9
LOI	95.95	2.88	0.80	13	90.2-101.5
			Basilar Length		
LOIII	81.70	2.22	0.26	72	74.5-87.3
LOII	78.79	2.29	0.37	38	74.5-83.7
LOI	76.11	2.26	0.63	13	71.4-79.5
			Length of Nasals		
LOIII	42.60	1.77	0.21	70	37.4-46.3
LOII	42.20	2.28	0.37	39	37.2-45.7
LOI	39.40	1.99	0.55	13	36.0-42.7
			Width of Nasals		
LOIII	21.71	1.23	0.15	68	18.6-24.4
LOII	21.86	0.94	0.15	41	19.5-24.0
LOI	20.34	1.46	0.38	15	18.5-23.9
			Zygomatic Breadth (I)		
LOIII	51.62	0.93	0.10	82	49-5-53.8
LOII	51.09	1.20	0.19	40	49.0-53.4
LOI	49.94	1.19	0.33	13	47.9-52.5
			Depth of Rostrum		
LOIII	26.84	1.02	0.12	77	24.3-29.5
LOII	26.92	1.03	0.16	41	25.2-28.9
LOI	24.97	1.19	0.31	15	23.0-27.4
			Cranial Breadth		
LOIII	35.30	0.92	0.10	82	33.3-38.4
LOII	35.06	1.00	0.16	41	33.1-36.8
LOI	34.51	1.34	0.37	13	32.9-36.8

APPENDIX 4, continued.

Population	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Diastema Length		
LOIII	29.74	0.96	0.10	84	27.5-32.2
LOII	28.71	1.26	0.20	41	26.2-31.8
LOI	27.00	1.08	0.28	15	24.4-28.7
			Maxillary Tooth Row		
LOIII	19.68	0.61	0.07	83	18.5-21.5
LOII	19.27	0.53	0.08	41	18.3-20.4
LOI	19.02	0.68	0.18	15	18.0-20.2
			Width of Rostrum		
LOIII	26.47	1.23	0.13	84	22.5-29.3
LOII	26.08	1.38	0.22	41	23.2-29.4
LOI	24.35	1.38	0.36	15	22.9-27.6
			Zygoma Length		
LOIII	44.08	1.27	0.14	82	40.3-47.2
LOII	43.10	1.35	0.21	41	40.7-46.3
LOI	41.25	1.50	0.40	14	39.1-44.9
			Inion-Incisor Length		
LOIII	101.02	2.17	0.25	73	95.3-106.4
LOII	97.98	2.40	0.39	38	92.9-103.5
LOI	94.69	2.63	0.73	13	84.1-99.1
			Greatest Length (II)		
LOIII	106.89	2.32	0.27	72	100.4-112.1
LOII	103.68	2.57	0.42	38	98.7-111.3
LOI	100.44	2.97	0.82	13	94.2-105.7
			Condylobasal Length		
LOIII	95.31	2.28	0.27	71	88.0-99.9
LOII	92.15	2.41	0.39	39	88.0-97.7
LOI	89.30	2.61	0.72	13	84.2-93.8
			Length of Incisive Foramen		
LOIII	26.45	0.88	0.10	83	23.9-28.4
LOII	25.21	1.25	0.20	41	23.0-27.8
LOI	24.29	0.91	0.24	15	22.3-25.6

APPENDIX 4, continued.

Population	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
		Breadth across Auditory Bullae			
LOIII	34.05	1.10	0.13	71	31.3-36.7
LOII	33.38	1.29	0.20	40	30.9-35.9
LOI	32.90	1.41	0.39	13	30.4-34.9
		Zygomatic Breadth (II)			
LOIII	53.82	1.44	0.17	76	50.0-56.9
LOII	52.53	1.72	0.28	38	49.0-55.8
LOI	51.53	1.97	0.55	13	48.5-55.1
		Interorbital Breadth Anterior			
LOIII	26.03	1.54	0.17	84	22.8-29.7
LOII	26.16	1.35	0.21	41	23.0-28.8
LOI	24.31	2.11	0.55	15	21.9-30.4
		Interorbital Breadth Posterior			
LOIII	16.72	0.89	0.10	84	14.5-18.8
LOII	16.64	1.17	0.18	41	14.9-19.6
LOI	16.81	0.91	0.24	14	15.4-18.5
		Length of Palatal Bridge			
LOIII	10.97	0.79	0.09	83	9.0-13.0
LOII	10.86	0.89	0.14	41	9.2-12.5
LOI	9.76	0.76	0.20	15	8.3-11.0
		Breadth across Upper Molars			
LOIII	29.49	0.76	0.08	83	27.8-31.1
LOII	29.40	1.49	0.23	41	25.9-31.8
LOI	28.75	1.10	0.28	15	27.2-31.6
		Greatest Length of Mandible			
LOIII	82.56	2.08	0.23	81	74.9-87.0
LOII	80.67	2.21	0.35	39	76.4-86.6
LOI	77.48	2.65	0.71	14	72.6-82.0
		Greatest Depth of Mandible			
LOIII	52.13	1.49	0.17	82	48.1-56.0
LOII	52.24	1.81	0.29	40	49.0-55.7
LOI	49.17	1.67	0.45	14	46.5-53.2

APPENDIX 4, continued.

Population	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Incisor-Basisphenoid Length		
LOIII	68.96	1.82	0.20	80	63.3-73.7
LOII	66.68	2.09	0.33	41	62.2-71.6
LOI	64.48	1.86	0.50	14	60.2-67.5

LOIII = Northern Population

LOII = Central Population

LOI = Southern Population

APPENDIX 5. Comparison of weight and body measurements of the four *Lepus* species.

Species	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Weight		
LO	4805.9	539.0	59.2	83	3900-6492
LA	4464.7	1041.3	268.9	15	2900-6350
LT					
LTW					
			Total Length		
LO	657.9	24.7	3.4	54	570-690
LA	635.2	41.7	6.9	37	541-711
LT	563.2	20.8	5.2	16	520-600
LTW	615.2	26.4	8.8	9	575-650
			Tail Length		
LO	69.4	15.1	2.2	49	25-114
LA	67.0	14.9	2.4	37	40-101
LT	62.4	12.6	3.1	16	46-86
LTW	9.7	9.7	3.2	9	82-108
			Hind Foot Length		
LO	184.9	7.7	0.8	90	152-197
LA	156.9	6.9	1.1	36	142-178
LT	170.5	10.0	2.5	16	156-187
LTW	152.2	7.3	2.4	9	143-164
			Ear From Notch		
LO	91.4	4.8	0.5	82	82-114
LA	90.7	26.6	15.4	3	68-120
LT					
LTW					
			Body Length		
LO	599.0	23.3	2.7	77	505-643
LA	570.9	40.8	6.9	35	469-640
LT	500.5	18.7	4.7	16	455-529
LTW	522.2	18.3	6.1	9	490-546

LO = *Lepus othus*; LA = *Lepus arcticus*; LT = *Lepus timidus*; LTW = *Lepus townsendii*

APPENDIX 6. Comparison of the 24 skull measurements of the four *Lepus* species.

Species	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Greatest Length (I)		
LO	100.12	2.75	0.23	138	90.2-106.3
LA	98.77	4.66	0.93	25	90.3-106.1
LT	90.86	3.19	0.55	33	86.1-103.6
LTW	90.91	3.66	1.16	10	83.8-95.4
			Basilar Length		
LO	80.17	2.91	0.26	128	71.4-87.3
LA	77.56	4.93	1.01	24	69.9-89.0
LT	72.71	2.88	0.51	32	68.8-84.6
LTW	72.69	2.98	0.94	10	67.4-76.2
			Length of Nasals		
LO	42.09	2.20	0.20	126	36.0-46.3
LA	41.77	2.45	0.52	22	38.5-46.5
LT	37.83	2.30	0.39	34	34.8-44.7
LTW	39.31	2.84	0.90	10	34.2-43.5
			Width of Nasals		
LO	21.62	1.25	0.11	128	18.5-24.4
LA	20.79	1.34	0.29	22	18.5-22.7
LT	20.19	1.44	0.25	34	18.1-24.2
LTW	20.88	1.32	0.42	10	18.4-22.7
			Zygomatic Breadth (I)		
LO	51.31	1.14	0.10	139	47.9-53.8
LA	49.76	1.77	0.36	24	47.1-53.1
LT	47.62	1.60	0.28	32	43.7-52.0
LTW	45.14	1.32	0.44	9	43.0-46.7
			Depth of Rostrum		
LO	26.67	1.18	0.10	138	23.0-29.5
LA	25.39	1.42	0.30	22	22.9-28.0
LT	23.57	1.30	0.22	34	21.4-26.3
LTW	24.09	1.33	0.42	10	22.6-27.0

APPENDIX 6, continued.

Species	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Cranial Breadth		
LO	35.17	1.00	0.08	141	32.9-38.4
LA	34.76	1.34	0.27	25	32.5-37.3
LT	33.24	1.08	0.19	32	30.6-35.2
LTW	32.43	0.85	0.27	10	31.2-33.8
			Diastema Length		
LO	29.11	1.37	0.11	145	24.4-32.2
LA	28.84	1.76	0.35	25	26.0-32.1
LT	25.98	1.58	0.27	34	23.6-31.1
LTW	27.19	1.55	0.49	10	23.9-29.1
			Maxillary Tooth Row		
LO	19.48	0.63	0.05	144	18.0-21.5
LA	18.37	0.93	0.19	25	16.6-19.9
LT	18.02	0.87	0.15	34	16.7-20.9
LTW	16.62	0.78	0.25	10	15.9-18.0
			Width of Rostrum		
LO	26.17	1.45	0.12	145	22.5-29.4
LA	25.24	1.27	0.25	25	22.7-27.7
LT	24.11	1.67	0.29	34	21.4-28.0
LTW	24.81	1.29	0.41	10	23.1-27.6
			Zygoma Length		
LO	43.56	1.59	0.13	142	39.2-49.1
LA	40.15	2.80	0.57	24	26.5-49.7
LT	39.48	1.69	0.29	33	35.2-44.2
LTW	36.12	2.55	0.81	10	30.2-38.9
			Inion-Incisor Length		
LO	99.32	3.11	0.27	129	89.1-106.4
LA	96.16	4.60	0.94	24	87.8-103.6
LT	90.25	3.04	0.54	32	86.5-102.6
LTW	90.84	3.69	1.17	10	83.8-95.3

APPENDIX 6, continued.

Species	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Greatest Length (II)		
LO	105.17	3.27	0.29	128	94.2-112.1
LA	103.04	5.24	1.07	24	93.8-111.8
LT	95.63	3.41	0.60	32	91.0-109.5
LTW	95.40	3.92	1.24	10	87.9-100.1
			Condylobasal Length		
LO	93.63	3.10	0.27	128	84.2-99.9
LA	91.21	4.64	0.95	24	83.2-99.1
LT	85.29	3.20	0.57	32	81.3-98.4
LTW	84.50	3.47	1.10	10	78.7-88.3
			Length of Incisive Foramen		
LO	25.84	1.27	0.11	144	22.3-28.4
LA	24.03	1.28	0.26	25	21.7-26.8
LT	22.95	1.35	0.23	34	20.7-26.8
LTW	24.19	1.48	0.47	10	21.5-25.9
			Breadth across Auditory Bullae		
LO	33.72	1.26	0.11	129	30.4-36.7
LA	32.50	1.65	0.34	24	29.1-35.0
LT	31.73	1.20	0.21	32	28.7-34.5
LTW	30.68	1.48	0.47	10	28.3-33.5
			Zygomatic Breadth (II)		
LO	53.21	1.78	0.16	131	48.5-56.9
LA	51.39	2.50	0.53	22	48.0-55.7
LT	48.40	1.77	0.32	31	45.0-52.9
LTW	45.25	1.87	0.66	8	41.3-47.4
			Interorbital Breadth Anterior		
LO	25.88	1.64	0.14	144	21.9-30.4
LA	23.72	1.71	0.34	25	20.7-27.2
LT	23.16	1.46	0.25	34	21.3-27.9
LTW	22.48	1.18	0.39	9	20.7-24.3

APPENDIX 6, continued.

Species	Mean	Standard Deviation	Standard Error of Mean	Sample Size	Range
			Interorbital Breadth Posterior		
LO	16.71	0.98	0.08	144	14.5-19.6
LA	17.01	1.37	0.27	25	14.6-19.9
LT	15.65	0.94	0.16	34	13.6-17.3
LTW	13.27	1.17	0.37	10	11.8-15.3
			Length of Palatal Bridge		
LO	10.78	0.89	0.07	144	8.3-13.0
LA	10.85	1.00	0.20	25	7.5-12.2
LT	10.76	0.80	0.14	34	9.3-12.5
LTW	9.47	0.84	0.27	10	8.2-10.6
			Breadth across Upper Molars		
LO	29.38	1.07	0.09	144	25.9-31.8
LA	27.86	0.95	0.19	25	26.3-29.2
LT	27.34	1.01	0.17	34	25.5-30.2
LTW	26.00	1.62	0.51	10	23.7-28.5
			Greatest Length of Mandible		
LO	81.48	2.66	0.23	138	72.6-87.0
LA	79.30	4.10	0.87	22	72.6-86.8
LT	74.51	3.16	0.55	33	70.9-84.3
LTW	72.38	3.11	0.98	10	66.1-76.2
			Greatest Depth of Mandible		
LO	51.87	1.83	0.15	140	46.5-56.0
LA	49.05	2.28	0.50	21	45.7-53.2
LT	48.46	2.07	0.36	34	45.2-54.4
LTW	44.59	2.25	0.71	10	41.2-48.1
			Incisor-Basisphenoid Length		
LO	67.77	2.42	0.20	140	60.2-73.7
LA	65.33	3.26	0.65	25	60.0-71.0
LT	61.47	2.23	0.39	32	58.8-70.4
LTW	61.55	2.22	0.70	10	57.2-64.4

LO = *Lepus othus*; LA = *Lepus arcticus*; LT = *Lepus timidus*; LTW = *Lepus townsendii*.

APPENDIX 7. Discriminant multipliers for assigning skulls to *Lepus* species as determined by four group multiple discriminant analysis.

Character	Species			
	Lepus othus	*L. arcticus*	*L. timidus*	*L. townsendii*
Greatest Length (I)	9.794	11.602	8.284	8.485
Zygomatic Breadth (I)	22.393	21.814	21.445	19.099
Maxillary Tooth Row	11.424	7.856	11.242	7.421
Zygoma Length	3.928	2.974	3.299	2.025
Inion-Incisor Length	-1.728	-3.702	-1.677	1.632
Condylobasal Length	-7.300	-5.685	-6.011	-8.274
Length of Incisive Foramen	-1.483	-3.298	-2.240	-0.960
Constant	-813.883	-767.856	-695.205	-628.014

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